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ART. XXXII.—*Address of* GEORGE BENTHAM, Esq., F.R.S., *President, read at the Anniversary meeting of the Linnean Society on Friday, May* 24, 1867.

IN my address of 1865 I attempted a general sketch of the more important Transactions of Scientific Societies or Scientific Journals in which papers on Zoology or Botany are being published, passing over, however, for want of time and space, those in the English language, beyond a mere mention of their titles. I have been since requested to resume the subject, in so far as the North American publications are concerned; and I the more readily avail myself of this opportunity of doing so, as there are some points in regard to their proceedings on which it may be useful to institute a comparison with those of European institutions. In this review, however, I meet with one difficulty; I have never been in America, and have no personal experience of the working of their institutions, as I had of so many of the European ones, and am obliged to collect the data from their published reports. I trust, therefore, my friends across the Atlantic will excuse any errors I may have committed through inadvertency, or any material points I may have passed over from ignorance.

Our American colonists before the outbreak of the war of Independence had already begun to turn their attention to the cultivation of science, and especially to the investigation of the rich and varied fauna and flora of their territory, and several Societies or Academies for the promotion of these studies and the publication of transactions on the model of European ones were

founded, either immediately before the great contest, or during the first years of the settlement of the States.

The American Philosophical Society, held at Philadelphia for promoting useful knowledge, was established in 1769, and soon commenced their 4to Transactions, the 1st volume having apparently been published in 1771, although, for some reason unknown to me, it bears the date of 1789. It contains nothing bearing upon Biology, except a few practical agricultural or horticultural papers; and the publication was interrupted during the years of trouble, until the Society was reorganized in 1780. A second volume is dated 1786, and four more complete the first series, which was closed in 1804 with the sixth volume. It contains, amongst a great variety of subjects, a few, mostly short, zoological papers chiefly in Ichthyology, Erpetology and Entomology by B. H. Latrobe, B. S. Barton, and Dr. Williamson, two small contributions to American Botany sent from Europe by Thunberg and Palisot de Beauvois, and an Index Floræ Lancastriensis by Muhlenberg. The labors of the Society appear then to have been suspended for nearly fourteen years; for it is only in 1818 that we find a new series commenced, and continued more or less steadily to the present time, the last received being two parts of the 13th vol. dated 1865. All are in 4to, but with gradually improving typography, paper, and illustrations, and a somewhat enlarged size adopted with the 10th vol., dated 1853. The series comprises all sciences among the subjects treated of; but a large proportion of the papers are devoted to the investigation of the Natural History (including Biology, Geology, Ethnology, and Linguistics) of the United States. J. Lea's malacological papers are perhaps the most extensive, going through nine out of the thirteen volumes. Entomology is next in order, in the earlier volumes by T. Say and N. M. Hentz, in the latter ones by J. L. Leconte, with a paper on Coleoptera by S. S. Haldeman, and another on Myriapoda by H. C. Wood, Jr. In other branches of Zoology, E. Hallowell on the reptiles of Cuba and the United States, S. F. Baird's Zoology of the Upper Missouri, and J. Leidy's papers, chiefly physiological or paleontological, are the most important, the contributions to Mammology, Ornithology and Ichthyology being few and short. In Botany there are several of Nuttall's descriptions of plants collected during his various expeditions, an enumeration of no less than 3,098 North American Fungi by L. D. de Schweinitz in the 4th vol., G. Engelmann's Botany of the Upper Missouri, E. Durand's Botany of the Great Salt Lake, and a few short contributions of minor importance. In 1838 the Society also commenced publishing their Proceedings in 8vo, after the model of European Societies. Of these we have 9 vols., from 1838 to 1864, including several papers of considerable length, occasionally illustrated by plates,

but chiefly on Physical Sciences, Geology, or Paleontology. In Biology there is nothing beyond a few abstracts for the purpose securing priority of names, or short communications of very little importance.

The diminished proportion of Natural History papers in the later volumes of the Philosophical Society's publications is fully accounted for by the activity of another Society in the same city devoted exclusively to Natural Science. This Academy of Natural Sciences of Philadelphia was established early in 1817, and immediately began the publication of the 'Journal of the Academy of Natural Sciences in Philadelphia,' in 8vo, issued in parts at irregular intervals, with a few plates. The first series of 8 vols., from 1817 to 1842, was chiefly a receptacle for short papers in almost all branches of Zoology, as well as in Geology and Mineralogy, with a very few botanical contributions by T. Nuttall, G. Elliot, L. D. de Schweinitz, and S. W. Conrad, all of little importance.

In 1841 the Academy commenced publishing their Proceedings in 8vo, at short intervals, forming 8 vols., for the years 1841 to 1856 inclusive, and since then one volume (not numbered) for each year, from 1857 to 1865, the last received. They contain short communications, abstracts of the longer papers intended for the Journal, and some entire papers of greater length, with a few illustrations, woodcuts, or lithographs; and in some of the earlier volumes J. Cassin's Ornithological papers are accompanied by colored plates. In these 17 vols., will be found a valuable record of observations and numerous descriptions of North American species in almost every department of Zoology.

In 1847 the Academy resumed the publication of the more extended papers in a work issued as a new series of the Journal, but in a large 4to form, with plates executed in a superior manner, many of the zoological ones colored; corresponding, in short to the Transactions of other Societies. The five volumes issued up to 1863, besides a few papers on exotic animals or on general subjects, contain important and valuable contributions to the Zoology of the United States, amongst which may be particularly mentioned the papers in Ornithology by J. Cassin, Erpetology by E. Hallowell, Malacology and Conchyliology by I. Lea and T. A. Conrad, and Entomology by J. L. Leconte and R. Clemens, besides shorter communications in various branches of Zoology by naturalists of note. Botany is limited to Nuttall's account of Gambel's plants, a paper by M. J. Berkeley and M. A. Curtis on Fungi, and E. Durand's accounts of Heermann's and of Pratten's collections.

In this Journal I observe that the date of issue of the author's copies of each separate paper is given in a note to the table of contents. This is no doubt with a view to fixing a

date on which the priority of discovery or of names is to be established. It has been universally acknowledged that priority depends upon the date of publication; but it has been a much debated question what amounts to a publication so as to fix that date. Is it to be the time when a paper is read, or when it has gone through the press so as to prevent any further alterations on the part of the author, or when it is actually given out for sale, or simply the date it bears on the title page? I believe that at the Royal Society the date of reading a paper is considered as a sufficient publication to establish rights of priority in a discovery or invention, and, in a legal point of view, with reference, for instance, to the law of patents, it seems reasonable that it should be so; for it is not fair that an inventor should obtain the sole right to his invention when the same or a similar one had been produced at the same time or before him, although not in a manner in which he could have cognizance of it; and for establishing such a fact the reading of a paper may be sufficient evidence. Both inventors can then enjoy the credit and benefit of their invention, but neither of them to the exclusion of the other. This also supposes that no alteration is allowed in a paper after it has once been read, unless it be clearly designated by brackets or otherwise, as I believe to be the practice of the Royal Society. In Biology, however, the case is different, the object is not only to establish that priority or rather independence of observation or discovery which can be enjoyed equally by two or more naturalists, but also the priority of name, which is a more complicated question, for an animal or plant cannot retain two names; when, therefore, it is found that it has been differently named by two or more naturalists it is necessary to decide which one should be exclusively adopted. In principle, it is the universal rule among botanists, and, I believe, a general one among zoologists, that, supposing there is no absolute objection to either name, that one is to be retained which was first fixed by actual publication,—its insertion in a work on sale or in general distribution, accompanied by diagnostic characters or other indications intended to fix its identity. The reading a paper at a meeting of a Society is not a publication for this purpose, only because it does not give fixity; the author himself does not feel bound by it and (possibly from the discussion evoked or observations made at the reading) may alter his names before or during the printing. A purely technical paper is, indeed, not even actually read, and often laid before the meeting in an unfinished state, the substance of it being verbally explained. The other objection, as to the impossibility of a naturalist not actually present having cognizance of a paper read at a meeting until it is in print is only one of degree, and may even tell the other way, for he

may see it in print long before he can possibly procure a rival one from the antipodes although previously published.

It being admitted, then, that the date of a name is that of its actual publication, there still remains sometimes the practical difficulty of determining when that publication took place. *Primâ facie* evidence is the date given on the title-page of the work, but that is occasionally unfairly erroneous. The whole of Rees's Cyclopedia, in which much Zoological and Botanical matter is original, bears on the title-pages the date of 1819, when some of the volumes were published nearly twenty years earlier. Presl's Botanische Bemerkungen, with innumerable new or altered names of plants, is dated the second year before it was on sale. The Annales des Sciences Naturelles are notoriously antedated by several months. Grisebach's Monograph of Gentianeæ, dated 1839, was received in this country the previous November. The first parts of Ecklon and Zeyher's Enumeratio, and of Ernst Meyer's Commentatoines on South African Plants, each describing as new or renaming two or three hundred species of Leguminosæ, many of them identical in the two works, appeared almost simultaneously; but Ecklon and Zeyher's was actually published, as dated on the cover, in January 1836, whilst E. Meyer's, which was not issued to the public till the 14th of February 1836, has the ostensible date of December 1835. In order to do justice to the authors under similar circumstances extrinsic evidence has been generally admitted to correct the dates apparent on the title. In the case of Transactions of Scientific Societies this extrinsic evidence, often difficult to establish, is particularly required. There are generally two dates given, that of the reading, affixed to each paper, and that of the completion of the volume, given on the title-page; the former would be unfair to the rival observer, who might be superseded by alterations made after the reading of the paper, the latter equally unfair to the author, whose memoir, if in the first part of the volume, may have been in the hands of the public for years before the apparent date. In some Transactions this is remedied by printing the date of publication of each separate part; but even that is not always enough, for author's separate copies have sometimes been generally circulated, and even on sale, a considerable time before the complete part to which they belong. It is for the purpose of fixing this date (which ought surely to be admitted as a sufficient publication) that in the Philadelphia Journal the date of issue of the author's copies is, as above mentioned, noted in the table of contents. We have been considering whether a similar plan might not be adopted for our own Transactions, but it has been thought unnecessary to make the alteration, for the cases are very few where the author's copies are ready for delivery much before the

part in which they are contained; and since we have regularly issued a part every autumn, the whole of the papers read during a session are thus actually published within a few months of the close of that session, thus always bearing the date of the same year. Where, however, as in some foreign Transactions, the author's copies are sometimes circulated a year or more before the part they are contained in is actually published, the noting the date of the former appears to be essential.

We are this moment in receipt of the 4th, 5th, and part of the 6th volume of the Proceedings of the Entomological Society of Philadelphia in large 8vo, with a few plates; edited by Mr. Cresson.

Boston was not long in following the example of Philadelphia in the foundation of a central scientific body. The American Academy of Arts and Sciences was established at Boston in 1780, and a few years afterward commenced the publication of 4to Transactions, entitled 'Memoirs of the American Academy of Arts and Sciences.' A first series of four volumes, dated from 1785 to 1821, contains, however, but little on Natural History, and from that date there appears to have been a long interruption. In 1833 a new series was commenced, with improved typography and illustrations. Of this we have seven volumes, from 1833 to 1860, and the first two parts of the 8th volume, dated respectively 1861 and 1863, when as in the case of other scientific works, the publication appears to have been suspended by the effects of the civil war. Although the majority of the papers in these Transactions are on mathematical, physical, linguistical, and other miscellaneous sciences, yet, in Natural History, they contain D. H. Storer's extended synopsis of the Fishes of the United States, as well as several detached papers of his on the Fishes of Massachusetts, Nuttall's account of the Birds of Massachusetts, some smaller contributions to insect anatomy by Haldeman and J. Leidy, and several important Botanical papers, including Sullivant's Bryology and Hepaticology of the United States, A. Gray's Plantæ Fendlerianæ, Notes on the Botany of Japan, and several minor papers, Grisebach's Plantæ Cubenses Wrightianæ, and Eaton's Filices Cubenses Wrightianæ et Panamenses Fendlerianæ.

In 1846 the Academy also commenced 8vo Proceedings, published at shorter intervals than the Memoirs, and forming six volumes, from 1846 to 1865. Besides the ordinary reports of Proceedings and abstracts of the longer Memoirs, they include some entire papers of considerable length, especially J. D. Dana's Conspectus of the Crustacea of the Exploring Expedition under Wilkes, M. J. Berkeley and M. A. Curtis's Enumeration of the Fungi of the same Expedition, Tuckerman's Synopsis of North American Lichens, G. Engelmann's of North American Cactaceæ, and Anderson's of North American Salices.

The naturalists of Boston further followed the example of Philadelphia in the establishment of a Society specially devoted to their own sciences. Their first efforts, however, were not successful. A Linnean Society of New England was formed in the winter of 1814–15, and during two or three years several meetings were held, papers read, and a few collections formed; but their only publication was a Report read at a meeting of the Society on the 18th of June 1817, on the part of a Committee appointed to inquire into the facts relating to the Sea-serpents supposed to have been seen on their shores. This report, a curiosity in its way, consists chiefly of the examination on oath of a considerable number of witnesses, the result of which appears to have led the committee to conclude not only that Sea-serpents of sixty feet or more in length had really been seen, but that a *Scoliophis atlanticus* about three feet in length, actually captured and described and figured in the report, was the young of the same species. After this effort the Society languished, and was dissolved in 1822, and the remnants of the collections were finally disposed of in 1830.

In that year a new Society was formed, which appears to have been yearly increasing in means and activity. The Boston Society of Natural History in 1834 commenced publishing papers communicated to them in the Boston Journal of Natural History, in 8vo, with a few plates; and the seven volumes issued up to 1863 are replete with valuable contributions to almost every branch of the Zoology of their country, with a few botanical papers, especially the Plantæ Lindheimerianæ by Engelmann and Gray. In exotic biology there also are papers by S. Cabot on the Birds of Yucatan, by J. Wyman on the Gorilla, by T. W. Harris on African Beetles, by A. A. Gould on African Shells, and by L. W. Bailey on Microscopical Organisms of Para. The Society also publish their Proceedings in 8vo, now in the 10th volume (1841 to 1866), which, besides abstracts, include a considerable number of short systematic enumerations, diagnoses, &c., both in Zoology and Botany. Of late years, however, the Society appears to have devoted its chief energies to the formation of a Library and Museum. The printed reports give a very flattering account of the new building into which the Library and Museum were moved in 1864, and which had been erected at a cost, including the cases, of above 100,000 dollars; the Library is reported as consisting in 1865 of above 7000 volumes, besides 1800 parts of volumes and above 2000 pamphlets, and the Museum as being far richer in most branches of Natural History than one should have supposed that a private Society would have been able to maintain. It will be interesting to watch in future years how far the resources they can depend upon will enable them to provide for the proper care and

arrangement of their collections, which, to be useful, must be constantly and largely on the increase. The Treasurer's accounts show that besides the janitor (whom we should call porter) and some occasional help, there is but one paid officer, an eminent Entomologist, who is at the same time Custodian, Librarian, Recording Secretary, and Entomological Curator. For the thirteen other Curators of as many branches of Natural History, on whom alone depends the arrangement of the specimens, no remuneration appears in the accounts, whereas if the anticipations of increase sketched out in the Custodian's reports be realized, there must be full claims to the whole time of more than one Curator in most of these branches. The Society is making an experiment upon a large scale, but evidently depends much upon gratuitous aid; time alone will show whether that is less precarious on the other side than on this side of the Atlantic.

It is announced that the Boston Society's Journal is to be discontinued in the present form, but that the papers read will be published in quarto, under the new title of Memoirs of the Society.

The Harvard College at Cambridge contains a Museum of Comparative Zoology, which appears to be of great importance, and we understand that the very rich and valuable Herbarium of the distinguished Professor of Botany is also secured to the Botanic Garden of the University, but we know of no regular Transactions or Journals published in connection with the establishment.

The Lyceum of Natural History of New York was established in 1818, and commenced publishing the Annals of the Lyceum in 1823, in large 8vo, with a few plates. The seventh volume was completed in 1862, and the eighth is now in progress; they contain papers of considerable importance, chiefly in illustration of the Natural History of the States, including C. L. Bonaparte's Synopsis of North American Birds, some other papers in Ornithology by J. N. Lawrence and others, in Ichthyology by T. Gill, in Entomology by J. L. Leconte, J. W. Greene, and others, and numerous monographs and catalogues of shells by various conchyliologists. In Botany, Torrey's account of Rocky Mountain plants and United States Cyperaceæ, and L. de Schweinitz on North American Carices, occupy a considerable portion of the early volumes, beyond which there are only a few short communications from A. Gray.

The Elliott Society of Natural History of Charleston, South Carolina, published a volume of Proceedings, extending from November 1853 to December 1858, in 8vo, with a few plates. The most important papers are those of J. MacCrady on the Acalephæ of Charleston Harbor; among the smaller ones two are illustrated by plates, L. R. Gibbes on *Porcellana*, and a small list of rare plants by H. W. Ravenel.

The Academy of Science of St. Louis was established in 1856, and obtained an act of incorporation early in the following year. They publish Transactions and Proceedings in one continuous series under the former title, in 8vo, with a few plates; the first volume, a thick one, extends from 1856 to 1860, and two parts of the second are dated respectively 1863 and 1866. The papers relate chiefly to North American Fossils, with a few on various physical subjects, and one on an Egyptian *Papyrus*. In Biology there is little beyond Engelmann's monograph of *Cuscuta*, and other communications by the same author, more or less connected with the North American flora.

The only scientific journal published in the United States which I have met with is that which has acquired a worldwide reputation under the title of the American Journal of Science and Arts. It was commenced under the editorship of Professor Silliman in 1818, and published in parts in 8vo. After some interruptions during the first year or two, owing to the difficulty of arranging with the publishers, it has regularly formed two volumes in each year. A first series, conducted by Professor Silliman, and after the first few years at his own risk as proprietor, was closed in 1846 with the forty-ninth volume, a fiftieth being soon after added, made up of a general Index. Professor B. Silliman was then associated with his father, who has since died, and now conducts it at New Haven in conjunction with Prof. J. D. Dana, with the assistance of several other Professors of Cambridge and New Haven. It is now in the forty-third volume of the second series, having undergone but little change beyond a reduction in bulk from 1864, necessitated by the difficulties resulting from the war. In this journal Biology occupies less space than other sciences; there are, however, a few valuable papers in both Zoology and Botany, and under the head of scientific intelligence, every number contains critical notices or abstracts of works and other doings in Biology, which are always of great interest on this side of the water as well as in the States.

Washington is the seat of an Institution which, although not coming precisely within the definition of a Scientific Society, contributes largely to the promotion of our own, amongst other sciences, by publications after the model of Transactions of Academies, as well as by other means. It is, moreover, of a nature so different from any we have in this country, that it may not be out of place to enter into some detail as to its history, as gathered from the official reports, as well as from what we have experienced of its action. The founder was an Englishman, James Smithson, described as a graduate of the University of Oxford, who, having devoted a long life to the pursuit and encouragement of science, bequeathed his large property to the

United States, in trust, to found, at Washington, an Institution which should bear his name, and have for its objects the increase and diffusion of knowledge amongst men. The greater part of the property was realized in 1838, but considerable delay occurred in its application, owing chiefly to the great difference of opinion that prevailed as to the character to be given to the Institution, the objects of which were so vaguely indicated by the testator under these two heads, the increase and the diffusion of knowledge. At length, on the 10th of August, 1846, an Act of organization was passed by Congress, and the 'Smithsonian Institution for the increase and diffusion of knowledge' was established at Washington, under the management of a Board of Regents, fifteen in number, consisting of the Vice-President of the United States, the Chief Justice of the Supreme Court, and the Mayor of Washington, as *ex officio* members, three appointed by the Senate from its own body, three by the House of Representatives from its members, and six citizens appointed by a joint resolution of both houses; several of the principal executive officers of the States to be *ex officio* members, with occasional honorary members to be elected by the Regents. The total amount of the bequest received into the United States Treasury on the 1st of September, 1838, was 515,169 dollars, or above £125,000, deposited in the United States Treasury, and producing an annual income of $30,910, payment of which they have succeeded in obtaining in coin, making nearly £7000. There was also at the time of the establishment of the Institution an accumulation of interest amounting to $242,129, or nearly £55,000. For the application of these sums different schemes were strongly advocated by opposing parties. One, which found most favor with the national and popular party, was the formation of a general Library, Museum, and Gallery of Art in a building which, by its dimensions and architectural design, should be an ornament to the city, and a splendid memorial of the liberality of the founder; whilst others, entering more into the spirit of the bequest, urged that Smithson's object could never have been the glorification of Washington, or the localization of knowledge, but the promotion of science wherever or by whomever it was or might be pursued, and that the fund ought therefore to be employed in the encouragement of scientific and literary researches, and to the publication and transmission of their results to every quarter of the globe where civilization could reach, with such buildings, collections, and local appliances only as should be immediately subservient to these objects. At length a temporary compromise was effected between the advocates of local appliances and of active operations. It was determined that, besides the deposited capital which, by the Act, was to be left untouched, a portion of the income was at

first, at least, to be annually invested, till the plans should be matured by experience, and that, of the remainder, one portion was to be expended in the formation of the library, museum, and gallery required by the Act, and the other in the more active operations recommended by men of science, whilst the accumulations already in hand were to be applied to the erection of the building, the relative proportions being left to the discretion of the Regents. During the first year the popular party found favor with the majority of them, and large sums were squandered on the building and local objects; but in time sounder views prevailed; the active operations have been extended with a success we all can appreciate, and the Institution has now attained a position of practical eminence and usefulness to science in strict conformity with the evident intention of the founder. This happy result (as far as I can judge from this distance, and without any personal communication) must be attributed mainly, if not entirely, to the well-devised plans of the Secretary, Prof. Henry, and to the zeal, activity, and perseverance with which he has devoted himself to their practical carrying out during the twenty years that have elapsed since the foundation of the Institution.

The edifice was originally to have been "a suitable one, constructed in plain and durable materials;" but the Building Committee, giving way to local influences, adopted a plan described in the Secretary's reports as being in the Lombard style, with useless buttresses, turrets, and towers, the convenience of the interior entirely sacrified to architectural display; a judgment which an inspection of the plans and elevations given in R. D. Owen's 'Hints on Public Architecture' fully confirms. The money thus lavished on the freestone facade absorbed so much of the sum at command that the interior had to be run up in wood, lath, and plaster. The two wings were thus completed, and the main building presenting a frontage of 200 feet was far advanced, when the woodwork gave way, and had to be replaced with fireproof materials at very large extra cost, the roof alone of this main building remaining in wood. In that roof, where little danger was forseen, a fire broke out through the carelessness of some workmen in June 1864, destroying much private property, official papers, &c., although the most valuable stores, library, and collections of the Institution were preserved. After these disasters the ruling powers appear at length to be convinced that in the work of restoration and completion they must look more to substantial durability than to architectural effect; but they are sadly hampered by the size of the building, so much beyond their real wants, and its costly style, which cannot now be altered. In this building were to be deposited:—

(1) A general National Library, with provisions by which

the Institution would be encumbered by all the trashy productions of the day, without means of procuring those really valuable to science; this they have succeeded in warding off, and are endeavoring to limit their library to works bearing on science. They have bestowed especial pains, and appear to be already rich in Proceedings and Transactions of learned Societies and other serials connected with science; and it is hoped that they will be gradually relieved from their general and useless literature by the transformation of the Congress Library into the great National United States Library, instead of attempting to impose the burthen on a private Institution incapable of sustaining it.

(2) A general Museum, as comprehensive and multifarious in its objects as our own British Museum, with a similar aim at popular display. But the impractibility of such a Museum, which would soon absorb an annual income equal to their whole capital, is now felt, and the collections are to be henceforth restricted—1st, to those made by the United States Exploring Expedition, the care of which has been imposed on the Institution by Congress; 2nd, a limited museum of type specimens, principally of the products of the American Continent, or such as are thought of especial interest as illustrating the Smithsonian publications; and 3rd, collections for distribution, to which I shall presently revert.

(3) A Gallery of Art; but the absurbity of imposing upon such an Institution the care and maintenance of a National Gallery is so evident, that the collections in this respect have been limited to some plaster casts of distinguished individuals, and a very few pictures they could not refuse the charge of.

In the active operations of the Institution the knowledge they are called upon to promote has been divided, as in the great Academies of the Continent of Europe, into the three great branches of Physical Science, Moral and Political Science, and Literature; the Fine Arts being nominally included in the latter class, but really somewhat extrinsic in character, and practically passed over. What has been effected by the Institution in the second and third classes, it is beyond my province to inquire; and even in the Physical class I do not venture to express any opinion on their efforts in the promotion of Meteorological, Astronomical, and other Physical observations. In Biology their exertions have been directed to the publications of Memoirs, Reports, and other papers, to the promotion of Exploring Expeditions, as well as of local investigations, to the distribution of specimens, and to the facilitating the interchange of publications and other vehicles of knowledge.

The principal publications of the Institution are in two series, the one in 4to, the other in 8vo, corresponding generally to the

Transactions and Journals of Scientific Societies. The 4to series, entitled 'Smithsonian Contributions to Knowledge,' copiously illustrated by well-executed plates, has now attained its 15th volume (although 14 only have as yet reached us,) the first having been published in 1847, less than a twelvemonth after the foundation of the Institution; the 8vo series was only commenced in 1862, without plates, and now forms six large volumes. In these two series Physical Sciences and Natural History (Biology, Paleontology, and Geology) occupy nearly equal proportions; there are also extended ethnological and philological Memoirs, and a few smaller ones on miscellaneous subjects. The Biological papers, whether systematic or physiological, are almost entirely illustrative of the fauna and flora of North America, the most important of which are (including two or three now in the press) Monographs or Catalogues of North American Bats by H. Allen; Mammals and Birds by S. F. Baird; Oology by T. M. Brewer; Reptiles by S. F. Baird and C. Girard; Cottoid Fish by C. Girard; Marine Invertebrata and Crustacea by W. Stimpson; Shells by W. G. Binney, P. P. Carpenter, T. Prime, W. Stimpson, and G. W. Tryon; Insects by J. L. LeConte, H. Hazen, H. Loew, F. E. Melsheimer, J. G. Morris, R. Osten Sacken, H. de Saussure, S. H. Scudder, and P. R. Uhler; in Animal Physiology by J. Dean, J. Jones, S. W. Mitchell, G. R. Morehouse, and J. Wyman; in Insect Embryology by L. Agassiz, and in Microscopic Biology by J. W. Bailey and J. Leidy. In Botany we have W. H. Harvey's Nereis Boreali-Americana, illustrated by 50 plates, A. Gray's Plantæ Wrightianæ Texano-Neo-Mexicanæ, and three papers by J. Torrey on Californian plants. Each one of these papers is separately paged in order to facilitate their separate distribution.

The Smithsonian reports form a volume in 8vo for each year; they contain, besides the official reports of the proceedings of the Institution for the preceding year, extracts from correspondence, reports of explorations, &c., several important scientific papers translated from foreign languages, and some original ones on various scientific subjects. These reports to Congress are printed at the expense of Government, with the exception of a few occasional woodcuts supplied by the Institution.

In the way of promoting explorations and collection of observations, the efforts of the institution have hitherto been judiciously confined as strictly as possible to America, Northern and Arctic, Central and Southern; but in this field they have done much, and the exertions of the Institution, with considerable means at its command, cannot but remind one of the equally strenuous and successful exertions, as to one branch at least of science, of a single individual in our own country, the late Sir William Hooker, or of the more general ones of our

Royal Geographical Society. On this subject I cannot do better than quote a passage from the Secretary's Report of March, 1865, when speaking of the aid afforded in the organization of government explorations by land and by sea:—"Whether by official representations to the heads of departments or personal influence with officers and employés, it has secured the engagement of individuals competent to collect facts and specimens; it has instructed persons thus engaged and others in the details of observation, it has superintended the preparation and in some cases borne the expense of the necessary outfits, has furnished fresh supplies from time to time to the collectors while in the field; received the collections made and preserved them for future study, or at once consigned them to proper persons, both at home and abroad, for investigation, directing the execution of the necessary drawings and engravings for the reports, and finally superintending the printing and even the distribution of any available copies of the completed works to Institutions of science. Prior to the establishment of the Institution but little had been done by the Government in the way of scientific explorations, with the exception of that under Captain Wilkes. But since then, nearly every United States expedition, whether a survey for a Pacific Railroad route, a boundary line, or a wagon route across the Rocky Mountains, or an ordinary topographical expedition, has been influenced or aided more or less as above stated. Besides these, similar explorations have been carried on without any reference to Government, and either entirely or in a great measure at the expense of the Institution and always at its suggestion." An enumeration follows of above twenty of the more important of these expeditions directly organized by the Institution in the northern and western portions of North America, in Mexico, Central America, Cuba, Jamaica, and Bolivia.

In making collections by means of these expeditions or otherwise, the object has not been so much to supply a large museum with permanent specimens, or duplicates for regular exchanges, as to distribute the specimens where it is thought they might best advance the cause of science, by being most accessible to the largest number of students engaged in original investigations. Much has been done in this way in the encouragement of local societies in rural districts for the collection of specimens and the recording of natural phenomena; and, as far as botany at least is concerned, the collections that come to Europe show that the official statements on this head are not extravagant boasts.

I have said that in its Library the Institution is endeavoring to obtain a complete collection of Transactions and other works of a serial character issued by learned bodies. This they ex-

pect to obtain chiefly by a liberal system of exchange, and for that purpose it is now in correspondence with upwards of 1200 of the Societies, Public Libraries, and principal Universities of of the Old World.

The last head I shall refer to is that of International Exchanges. From the first, one of the special objects of the Secretary's plans was to facilitate the direct correspondence between the learned institutions and scientific men of the two worlds, and the free exchange of their publications. Year by year the plans for this purpose have been modified and improved until they have attained an extent which seems only to require control to guard against its being abused by private interests under the name of science, or, perhaps still more, of benevolence. At the present time the Institution receives, at periods made known through its circulars, any books or pamphlets of scientific, literary, or benevolent character which any institutions or individuals in America may wish to present to a correspondent elsewhere, subject only to the condition of being delivered in Washington free of cost, and being accompanied by a separate list of the parcels sent. Where any party has any special works to distribute, the Institution is prepared to furnish lists of societies or persons to whom they might be usefully sent. The articles and volumes, when received, are assorted, packed, and dispatched to the agents of the Institution in London, Leipzig, Paris, and Amsterdam. The boxes are there unpacked, and the contents distributed through the proper channels. The returns for these transmissions are received by the same agents, packed and forwarded to Washington, from which point the parcels for other parties are sent to their proper destination. All the expenses of packing, agents, freights, &c., between those four towns and Washington are borne by the Institution, the parties concerned only paying the local carriage from or to these great centers. In this interchange the Institution has obtained special facilities on the part of custom-houses, railroad and steamboat companies; and the scientific and literary world have largely availed themselves of this useful system. The number of packages reported as dispatched to foreign countries from Washington in 1864 was 1011, contained in 63 boxes, weighing 20,500 lbs., whilst the packages received in return was 2482, exclusive of those for the Smithsonian library.

We have nothing of the kind in this country, and the difficulties of interchange of books and specimens with the Continent are much felt; the comparative cheapness of freights is more than made up by the complicated agencies and other extra charges, which can scarcely be avoided even by the few who are initiated into the secrets of the business. A box of specimens for Hamburg, which the carrier took to the wrong continental

steamboat agent in the city, cost me 22s., when for 25s., I might have gone myself to Hamburg and taken the box with me as luggage. The sending one or two volumes, or a small packet of specimens into Germany, is often prevented by the difficulties and expense attending it. It is not to be expected that any Association in this country should be endowed with funds especially devoted to the diffusion of knowledge, enabling them to undertake the transmission gratis of scientific works and specimens; but it appears to me that if, for instance, the six Scientific Societies which are in future to be assembled in this locality were to join in salarying agents in London and in three or four of the principal centers of science on the Continent, who should receive for transmission, pack, and periodically despatch scientific parcels, and distribute return packages, charging to individuals their proportions only of actual disbursements, the gain to science would be considerable and the charge to each society but small.

In glancing over the general tendency of the biological papers contained in the works I have ennumerated, it will be seen that, although it is scarcely half a century since our American brethren applied themselves in earnest to the investigation of the natural productions and physical condition of their vast continent, their progress, especially during the latter half of that period has been very rapid until the outbreak of the recent war, so deplorable in its effects in the interests of science as well as on the material prosperity of their country. That is, however, now fortunately over; and although the means of every scientific institution are still sadly crippled by the high prices and heavy duties resulting from that war, yet many of them appear to be resuming their former activity; and it is to be hoped that they will now again receive every encouragement, public and private, in the vigorous prosecution of their researches. The peculiar condition of the North American Continent requires imperatively that its physical and biological statistics should be accurately collected and authentically recorded, and that this should be speedily done. It is more than any country, except our Australian colonies, in a state of transition. Vast tracts of land are still in what may be called almost a primitive state, unmodified by the effects of civilization, uninhabited, or tenanted only by the remnants of ancient tribes, whose unsettled life never exercised much influence over the natural productions of the country. But this state of things is rapidly passing away; the invasion and steady progress of a civilized population, whilst changing generally the face of nature, is obliterating many of the evidences of a former state of things. It may be true that the call for recording the traces of previous conditions may be particularly strong in Ethnology and Archæology; but in our own branches of the science,

the observations and consequent theories of Darwin having called special attention to the history of species, it becomes particularly important that accurate biological statistics should be obtained for future comparison in those countries where the circumstances influencing those conditions are the most rapidly changing. The larger races of wild animals are dwindling down, like the aboriginal inhabitants, under the deadly influence of civilized man. Myriads of the lower orders of animal life, as well as of plants, disappear with the destruction of forests, the drainage of swamps, and the gradual spread of cultivation, and their places are occupied by foreign invaders. Other races, no doubt, without actually disappearing, undergo a gradual change under the new order of things, which, if perceptible only in the course of successive generations, require so much the more for future proof an accurate record of their state in the still unsettled condition of the country. In the Old World almost every attempt to compare the present state of vegetation or animal life with that which existed in uncivilized times is in a great measure frustrated by the absolute want of evidence as to that former state; but in North America the change is going forward as it were close under the eye of the observer. This consideration may one day give great value to the reports of the naturalists sent by the Government, as we have seen, at the instigation of the Smithsonian Institution and other promoters of science, to accompany the surveys of new territories. For present purposes we want very much a digest of the new observations. Synopsis of some classes of insects and other animals appear indeed in a complete, or nearly complete form in the Smithsonian and other publications above mentioned; but we have as yet no complete flora of North America. The admirable one began so many years since by Torrey and Gray has been so long interrupted that it requires rewriting from the beginning; and there is no greater service to the science that the distinguished Cambridge Professor could now render than the resumption of that work, in any, however much abridged form.

The American Museum reports suggest some topics worthy of consideration with regard to the general question of Natural History Collections. The first thing that strikes one is the want of a National Central Museum for the reception of as complete a representation as can be obtained of the North American Fauna and Flora, with so much at least of foreign specimens as may be required for comparison and generalization. For this they seem to have depended on the efforts of private scientific bodies; but the progress of these, so far as they have gone, seems to corroborate the experience of the Old World, that the useful maintenance of such an establishment is absolutely hopeless unless it be supported at the public expense, or by the an-

nual proceeds of a sufficiently large inalienable capital. In America, as in Europe, almost every Natural History Society, small or large, begins by contemplating the formation of a Museum, undefined as to limits; contributions are invited and donations thankfully received from every quarter, without reference to value or practical utility. At first, whilst the Librarian, Secretary, or other manager takes a personal interest in the arrangement and exhibition of the objects received, when donors can bring their friends to see their contributions displayed on shelves or in glass cases with their own names paraded on the cards, when most of the members of the Society have the new feeling of a personal share in the ownership of the collections, when the number of specimens received is blazoned forth as a matter of pride and gratification, these incipient museums may have considerable influence in stimulating collectors and observers of nature. But after a time these collections outgrow the Society's means, the specimens which may be required for study or comparison are encumbered by a mass of trash presented by persons who do not know what else to do with it, or who have attached a false value to the fruits of their own labors, the permanent officer can no longer have time to select for exhibition what is worthy of it, nor to arrange those which might be available for reference, and the Society cannot afford to maintain the necessary staff of keepers, even if they have a building large enough for the purpose. Packages and specimens are, however, still received, exhibited at meetings to elicit formal thanks, and then consigned to oblivion and decay in cupboards and garrets, the members generally taking no further interest in what they can make no use of. If afterwards attention is called to this state of things, it may be felt that something must be done; the gratuitous aid of patriotic members is called in, and the museum may be more or less purged of trash and partially arranged. But gratuitous aid, like voluntary subscriptions, is generally given on the spur of the moment, and can never be depended on for long continued and ever increasing demands; the collections relapse into a condition worse than the previous one, till at last the Society is obliged to dispose of them as a clog on, instead of an aid to, their operations. Such is the history of many a museum I could name on the Continent and at home, including our own, and such seems destined to be the career, on a large scale, of the Boston Society, notwithstanding its large invested funds, if something is not done to give it a permanent independence of individual disinterested efforts. It is now in the gratuitous aid period; but when its present stores are doubled or quadrupled, when the thirteen or fourteen unpaid curators must not only give their whole time to it, but require each of them one or more assistants to do the work usefully, it will not be done at

all; and unless the Society receives that extensive support which can only be expected from the State, stowage, neglect, and destruction must ensue. It is no doubt considerations such as these that have induced the Smithsonian Institution to repudiate the burthen attempted to be imposed on them of a National Museum which even the whole of their income would be insufficient to maintain.

There is another class of museums which the Smithsonian Institution appears to be promoting and assisting, with what results I have not sufficient means of judging; these are local museums on a smaller scale in the smaller cities and provincial towns. We have many such in Europe, both on the Continent and in our own country, and if judiciously formed and adequately maintained, ought to be very useful in encouraging the taste for observation at home, and giving the scientific visitor from a distance authentic information on the natural history of the district. But too many of them depend on the fluctuating support of voluntary contributions, and follow the fate of museums of societies. I have had occasion to go over many of these local museums in various parts of the Continent and some of our own, and it had been my intention to have collected information, and in one of my addresses to have prefaced some general observations on the subject, with a detailed review of all our provincial Natural History museums and Associations; but so many of them are unfortunately more or less in a state of collapse or uselessness, that I feared that special notes might be invidious. I may perhaps be allowed, however, generally to remark, that it appears to me that local provincial societies cannot better apply their funds and influence than in the establishment, on a permanent and independent footing, of a public museum, confining their publications to matters of purely local interest, which the general naturalist is not to be called upon to notice; that this museum should aim at completeness in representing the local district; that exotic specimens should be restricted to such a limited number of representative types or specimens for comparison as their means will afford, selected solely in proportion to their utility in the museum, without reference to the individuality of the donor, or, if a certain number of complementary specimens must be retained for a time in order to keep up the public interest in the establishment, such specimens be unhesitatingly expelled as soon as the cause for retaining them is gone.

In conclusion, I may perhaps be excused in alluding to some general principles in the management of large museums, which are inculcated by the Smithsonian Institution, more or less followed on the Continent, formerly almost ignored with us, but now more generally recognized. These are liberality of exchanges, facilities for study, and rejection of trash, principles

which it may be hoped are even gaining upon that most essentially conservative establishment, our gigantic and, I might almost add, all-grasping British Museum. The large sums annually voted for its support by the nation justify, indeed, not only the exhibition on a most extensive scale of attractive specimens for the occasional instruction or excitement to observation they may give to the general public, but also the concession to the popular party of a rare show for the thousands of gazers who would otherwise congregate for less harmless amusements; but a large proportion of the support or contributions to the museum is granted or given in the name of Science, and Science has a right to its full share in the consequent benefit. Whether Natural History be or not under the same roof as Art, Literature, and Archæology, Science has a claim upon Parliament to provide buildings and maintain a staff adequate to the scientific arrangement of the collections; and she has, I think, also a right to call on the management, be they a composite Board of Trustees or individual responsible heads, to reserve days, accommodation, and specimens for examination and study, to allow of the requisite appliances of light and heat in the process, to cause the stores that have accumulated for more than half a century to be turned out of their hidden repositories, to have what is useful to scientific researches rendered accessible for the purpose, the surplus duplicates employed in a liberal system of exchanges, with an eye quite as much directed to the distributing them usefully as to the pecuniary value of any expected return; and to authorize the consigning to the dust-cart all absolute rubbish occupying valuable space.

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ART. XXXIII.—*The Action of Sunlight on Glass;* by THOMAS GAFFIELD.

[Concluded from page 252.]

THE comparative power of glass of different kinds to transmit the actinic rays I have tested, by placing underneath pieces of each kind, pieces of easily changing glass, (white plate or Belgian sheet glass,) exposing them one year, and noticing, at the end of that period, the comparative depth of the yellow or pink color to which the under pieces had changed. The result of my experiments proved that the most easily transmissive of the colorless glasses were the English crown, French plate, two kinds of white crystal sheet made in Massachusetts, (from the celebrated Berkshire white sand,) the New Jersey sheet glass, one kind of English plate, and one kind of Belgian sheet, and about in the order which I have named them.

Of the colored glasses, the blue transmitted the most, the purple less, the red and orange the least, the glasses under these two and the yellow and green showing little or no change.

This last experiment proves the propriety of the preference given by photographers to blue glass for skylights, because it transmits the blue rays, which exert the most actinic power. But it may be added, that a colorless white glass, or bluish white,—if one which will not change by sunlight to a yellow or rose color, owing to the presence of manganese, or any other cause,—is equally good, as it will transmit all the rays, and among them, the actinic or blue ones. In proportion as any kind changes to a yellow or rose color, it will lose its power of transmission, and its value as photographic glass. I have seen specimens of the two kinds of white crystal sheet made in Massachusetts, before alluded to, which answered the demands of photographic artists. Of foreign glass, I have noticed a fine bluish white sheet, made lately without manganese, from a certain excellent manufactory in Belgium, and one kind of English crown glass.

Should plate glass be required, the most permanently enduring, or least likely to assume a yellow color, are a superior kind of white plate, made by the French and Belgian Plate Glass Companies, and an excellent quality of German crystal plate, made at a long established factory in Hanover.

I desire to say here, however, that it is not the place where any glass is made, which determines its good character, but the actual constituent materials and the superiority of its manufacture.

Manufacturers are frequently changing their mixture or "batch," so that any results given with one set of samples might differ from those made with another set, from the same manufacturers. For this reason, in noticing any differences which may occur in experiments made by any of our readers, this fact should be considered as an explaining cause.

I have seen specimens of glass from a factory which changed to a yellowish tinge in a few months, others which changed to a purplish hue, and still others from the same factory, which hardly changed at all. A difference in the mixture, (or batch, as it is termed), makes a difference in the tinge of the specimens from the same factory, both before and after exposure to sunlight. The chief points for photographers are to get glass made from as pure materials as possible, of as light a color as practicable, and free from oxyd of manganese. A glass like either of those named above, as most easily transmitting the actinic rays, might be good for one year or more, and then become very much injured for photographic effects, by the change of color to yellow or pink by sunlight.

Any photographer can make these observations practical, by testing the action of sunlight for six months or a year, on all the specimens offered him for sale. And all manufacturers can make them practical, by making their glass of pure materials, which will not have to be "doctored," to use the glass-makers' term for the use of manganese; or by allowing the glass to assume its natural color, even if it be a little blue or green, rather than to run the risk of its subsequent change to yellow or purple by exposure to sunlight.

In the Comptes Rendus for January 14th, 1867, Pelouze says, (and we believe he is the first and only writer who has made this observation):

"Exposure to red heat decolorizes the glasses which have been made yellow by sunlight, or to speak more exactly, they retake the light green shade which they had before exposure. A second exposure to sunlight produces a second coloration, similar to the first, and a red heat makes it disappear again. These phenomena can be reproduced indefinitely. The glass preserves its transparency and does not give place to any striæ or bubbles." He also says:

"I possess specimens of glass rendered violet by sunlight. All present the property of being decolorized by heat. A temperature of 350 degrees is not sufficient. It is necessary to have that employed in the reheating of glass in general, and that is in the vicinity of red heat. The glass decolorized by heat when exposed to sunlight retakes the amethyst color which it acquired the first time, loses it anew when it is heated; and these curious phenomena can be reproduced without cessation."

In confirmation of this most interesting statement of Pelouze, I have exposed in a glass stainer's kiln, several specimens of glass which had been changed by the action of sunlight, some to a yellow and some to a purple color. The exposure to an extreme red heat made the glass assume, some a white, some a yellowish white, and some a green color, which were probably the original colors. These specimens were taken from windows where they had been exposed from a few years to more than half a century. Further experiments, which I have already commenced, will show whether we can reproduce the exact original colors by heat, after being changed by exposure to sunlight.

We have in the same kiln exposed some dozen original and unexposed specimens of what are called colorless window glasses of different kinds and shades of color, and found them unchanged in the slightest degree by the action of great heat, while similar specimens have been changed in a few days, weeks or months, by the simple action of the sun's rays. Fifteen specimens of really colored glasses, (red, green, yellow, &c.,) have

been exposed in the same way without any change of color, except a very slight one in a few specimens which were burnt or over-heated.

In Poggendorff's Annalen, Berlin, of May 1st, 1839, is recorded the following interesting fact by A. Splittgerber:

"I would mention a curious fact, in which the sunbeams have, if I may say so, done something in the art of penmanship; not only on the surface, but by inscribing characters through the body of the glass; and, though the matter is based upon causes well known by experience, yet there has probably never before been so striking an instance of their effect known. I am in possession of a plate of glass which was used as a window pane for more than twenty years, and on which was an inscription in gold letters. This inscription was taken off by grinding the plate on both sides, and polishing it so as to have a new surface. When the glass had been polished, the inscription could again be clearly seen. The parts which had been under the letters remained white, while the remainder of the plate had assumed a violet tint, in consequence of the manganese it contained, a coloring which permeates the whole mass, as the grinding of the surface proved. The uncovered part of the plate, especially when laid upon a white background show the clearly readable characters."

The same or a similar instance is related by Dr. Herman Vogel in the Photographische Mittheilungen, Berlin, of Sept., 1866.

Desiring to produce a similar result, we made an inscription on a piece of Belgian sheet glass, in part with gold and silver leaf, and in part with black and white paint. The gold and silver leaf were soon washed off, but the black and white painted letters remained, and being removed after an exposure of nearly two years, the words stood out in clear contrast and full proportions, the inscription being in the original color of the glass, and the surrounding portions having been changed by the action of the sunlight to a purple color.

A very interesting experiment can be made, to show the gradually increasing effect of the sunlight on glass, by taking a piece of easily changing glass, say 4×20 inches, painting black a strip 4×2 inches at each end to preserve the original color, and then exposing the strip to sunlight. At the end of one, two, four, six, eight and ten months, one, two and three years respectively, cover with black paint a strip 4×2 inches, and at the end of three years remove all the paint, and you will have, in a single piece of glass, the original color and all the gradations of change effected by exposure from one to thirty-six months. I have made a similar one with Belgian sheet glass exposed nearly two years. It is one of those interesting experiments which speak for themselves, and defy suspicion or contradiction.

I have made an experiment for one year with two kinds of easily changing glass out of doors, and out of the direct rays of the sun, and found that they were both slightly affected, and changed toward a yellowish color. I did not expect any change, but can, perhaps, properly account for it, on the ground that it was the result of the action of diffused sunlight. It is barely possible that the sun may for a few minutes in some days of the year have cast some reflections when I was not present, in the dark corner in which I placed my specimens.

It may be, that the action of the sun's heat produced the slight effect noticed. If so, it would be an interesting confirmation of Tyndall's experiments, and of his theory of the correlation of forces. I do not consider my single experiment as entirely conclusive, and shall make others, which will give us more material for proper theories and conclusions.

The experiments which I have carried on for four years embrace one specimen of optical glass, a few kinds of flint glass and glass ware; sixteen kinds of French, Belgian, German and English plate glass, four kinds of American, English, French and Belgian rough plate, two of American and English crown glass, ten kinds of American, Belgian, French and English white sheet glass, four kinds of American, Belgian and English ordinary sheet glass, fifteen kinds and shades of English colored glass, four of opaque, white enamelled and ground glass, and one piece of the rough metal of American sheet glass; in all, about sixty varieties.

I have watched and recorded in some experiments, the results from day to day, in others from month to month, and season to season. I have now commenced a series, in which I may record results from year to year, for ten years or more. In these, it may be found that specimens of what are called colorless glasses changed to a yellow color by exposure for a year, may by much longer exposure be turned to a yellowish pink and a purple. And some which have been entirely unaffected, may be affected by an exposure for ten or twenty years. Perhaps some of the colored glasses may show signs of a change of hue or shade.

These new experiments include rough and polished plate, crown, cylinder, ground, enamelled and colored glass. I have also begun to expose *under* several of these kinds of glass, pieces of easily changing glass, which I shall take in from year to year, these *under* pieces showing the power of these glasses above them to transmit the actinic rays.

The most easily changing glasses are a certain kind of white plate, which changes from a white to a yellowish color, and a certain kind of Belgian sheet, which the manufacturers used to make of a brownish yellow, (they now make it of a bluish or greenish hue, and it is not so easily changed,) which changes to

a flesh color, or a pinkish hue. I have accordingly taken these two kinds, for my *under* glass experiments. Under each of several kinds, to be exposed from one to ten or twenty years, I have placed pieces 4×2 of the white plate. I shall take in one piece at the end of the first, second, third, fourth, sixth and tenth year. These six lights will show the increased action of the transmitted rays from year to year. By comparing the different series with each other, one can perceive the comparative actinic power of each kind of glass, or rather, their comparative power of transmitting actinic rays.

Another interesting *under* experiment is the following. I have placed under one piece of each kind of glass exposed, a piece of easily changing glass, which I shall take in at the end of the year.

At the beginning respectively of the second, third, fourth, sixth and tenth years, I shall place under the same piece, another strip of 4×2 inch glass, taking in each piece at the end of the year of its exposure. This series will show the diminishing or increasing power of the glasses under which they have been exposed, to transmit the actinic rays; in other words, will show whether exposure to the sun increases or diminishes the actinic power of the glasses exposed, and renders them better or worse for photographic purposes.

I have taken a piece of 4×18, of easily changing white plate, painted with black paint two inches of each end, to preserve the original color, and exposed the piece. At the end of the year, I shall paint over two inches more of the glass. At the end respectively of two, three, four, six, and ten years, I shall paint over two inches more. At the end of this time, or a longer term, I shall remove all the black paint, and on one light, I shall have all the grades of changed color and shade produced by their different lengths of exposure. I shall lay aside one piece of 4×18 white plate, taken from the same sheet with the exposed light, in order to compare the original with the changed specimen.

I have painted and exposed, just in the same manner as above described, a piece of 4×16 of easily changing Belgian sheet glass.

To show a speaking proof of the painting power of the sunlight, I have taken a piece of 4×6 Belgian sheet and covered it with a thin plate of brass, having the following letters cut out of it: T. G., Jan. 1, 1867. I have taken another piece 4×6 Belgian, and stuck on with gum shellac the two letters T. G. After exposure of one year or more, the removal of the brass plate and letters will show in the former case, rose or purple colored letters on a brownish yellow ground, and in the latter, brownish yellow letters on a rose or purple colored ground.

A similar experiment as the above, I have commenced with

two pieces of white plate, and the simple letters T. G., without the date. The result of the experiment in a year or more, will be to show in one case, yellowish letters on a light colored ground, and in the other, light colored letters on a yellowish ground.

I have thus given, as briefly as possible, and yet as fully as desirable, an account of my past and present experiments. New ones are suggested from year to year. I trust that this interesting field for observation and experiment may be worked in other countries. There is ample room for research in the application of chemical knowledge, of qualitative, quantitative, and spectral analysis, and of photogenic tests, to discover the exact action and causes of the interesting effects of the sun's rays, which have here been noticed.

*Theories.*—The interesting phenomena of which I have given an account, have given rise to many theories to account for their cause. Some attribute them to the presence of oxyd of iron, and some to oxyd of manganese. Exactly how the change takes place is a question on which writers differ, although it is my opinion that the precise explanation can only be given after a multiplication of experiments, and a thorough examination of exposed and unexposed specimens of glass by quantitative and qualitative analysis, and perhaps by spectral analysis and observation of photogenic effects, or photogenic tests.*

We will briefly state the part which the oxyds of iron and manganese play in glass making. In almost all kinds of window glass, and in some poorer qualities of flint glass, and glass ware, materials are used which are not perfectly and chemically pure. The sand, the carbonate or sulphate of soda, and the lime, one or all, contain slight impurities of iron, the protoxyd of which gives glass a green color. To correct this, after the batch is partially melted, a little oxyd of manganese, called *glass-maker's soap*, is put into the crucible or glass pot; some of the oxygen of the manganese flies off to the iron, and converts the protoxyd into peroxyd of iron. The peroxyd gives a yellowish color to the glass, and this, being complimentary to the natural pink of the manganese, is neutralized, and the glass is thereby made of a light color. When the sunlight acts upon glass thus made, the nice equilibrium between the oxygen of the iron and the manganese is disturbed, and sometimes the yellow, and sometimes the pink or purple color is produced. I have produced all shades of the purples, running from

* Since writing the above, by the kindness of Mr. John A. Whipple, the distinguished photographer of Boston, I have been enabled to show, by the comparative darkening of sensitive paper under several exposed and unexposed specimens, the effect of exposure to sunlight for one year. The loss of actinic power, or power to transmit the actinic rays, was in proportion to the change of color. This was in some varieties of glass quite perceptible, but in all will be more so after an exposure of several years.

pale lavender, into the lilac, mulberry, flesh, amethyst, rose, violet, pink and deep purple. I have produced, or seen specimens, showing all shades of the yellow, from the brownish yellow, up to the brightest gold color, and I have several series of specimens, in which the green has gradually changed into the yellow, and the yellow gradually run into the pink and purple.

Pelouze, in an article in the Comptes Rendus, of Jan. 14th, 1867, sets forth the following theory.

"There is in glass colored yellow in sunlight some protoxyd of iron and sulphate of soda. Light provokes between these matters a reaction from which results peroxyd of iron and sulphid of sodium. The heat brings about an inverse reaction and reproduces sulphate of soda and protoxyd of iron. From thence comes the return of the glass to its primitive color. Analysis comes to the aid of this theory in demonstrating in glass rendered yellow by sunlight, the presence of an infinitely feeble, but still very sensible proportion of a sulphid, whilst the reactions do not show the slightest trace in the same glass before their exposure."

"It may be asked, why glasses colored by the reduction of the sulphate, or the direct introduction of a sulphid into their mass, resist an equal or superior heat to that which produces the decoloration of glass become yellow in sunlight. Here is the answer. In glass made yellow at a high temperature by the reduction of sulphate, the iron is found in a state of protoxyd, which cannot react in any degree upon the sulphids. Therefore the glass remains colored. In glass made yellow by sunlight, the iron is peroxyd and in consequence, in a condition to change the sulphid into sulphate, when we expose the glass to the action of heat."

In reference to glass made violet color by sunlight, he says, "The coloration seems to be due to the fact that the peroxyd of iron gives up a part of its oxygen to the protoxyd of manganese conformably to one of the two following equations.

$$Fe^2O^3+MNO=2(FeO)+MNO^2$$

or $$Fe^2O^3+2(MNO)=2(FeO)+MN^2O^3.$$

The reheating of glass, that is to say, the action of a temperature of red heat, produces an inverse reaction, which explains the decoloration. In which we have

$$2(FeO)+Mn^2O^3=Fe^2O^3+2(MnO).$$"

Bontemps, in an interesting article in the Comptes Rendus of Feb. 4th, 1867, attributes the changes in color to the presence of oxyd of manganese. He also remarks that he thinks that the violet color occurs only in glass in which the silicates have a base of potash, and the yellow in cases where soda is used. I doubt the correctness of this opinion, as I am quite sure that I

have several specimens colored violet, which contain no potash at all in their composition.

I have also specimens which are colored both yellow and violet in the same piece, the yellow portion in one case having been produced by a certain length of exposure, and then having been covered with black paint, while the violet portion was produced by longer exposure.

As before stated, I have noticed changes in what are called colorless glasses, from light colors approaching white, to yellow and pink or purple. I have noticed also a change in a few specimens from a light green to a bluish shade. The former may be accounted for by the presence of manganese, a very minute proportion of which oxyd will have a sensible decolorizing effect in a crucible of melted glass metal. Pelouze's theory of the peroxydation of the iron may have some weight in determination of the cause of the yellow or pink color by the action of sunlight. But I know not how to account for the change of one specimen each of plate, crown, and sheet glass in my possession, from a greenish white to a bluih tinge, not mingled with either yellow or purple.

I have been pleased to find the interest in these experiments by photographers, who have long noticed that they could take better pictures under a newly glazed skylight, than under one which had long been exposed to sunlight. The cause of this change is, that the slightest yellow color interferes with the transmission of the actinic rays, and a very deep shade will cut them off in a very great degree. My experiments with glasses under other glasses proved which was best for photographers' use, information which all can gain by exposure of the specimens of various manufacturers which may be offered them. The most pure glasses of light green, or bluish white color are the best for photographers, and when I say *pure* glasses, I mean those most free from oxyd of iron or manganese, but especially of the latter, which, I think, is the cause of nearly all the changes which I have observed. Mr. J. W. Osborne, of New York, the gentleman who has done so much to bring the art of photo-lithography to perfection, and into practical use, writes as follows:

"I believe your researches will prove of much practical importance, and I wish the glass manufacturers could be got to give serious attention to the subject. It takes but a very slight tinge of yellow to cut off twenty-five per cent of the actinic rays. I am forced to work under glass, because of the protection from the wind and weather, but in doing so, I sacrifice in any case much of the light. I have to increase the time of exposure proportionately. With the best of glass, the loss from reflection and absorption is considerable. This may be fearfully increased by the color, and if that undergoes a continual change for the

worse, the state of things is exceedingly unpleasant. I was warned by a photographic friend in England, to take care of a certain kind of cheap French glass, made for glass rooms, which turned yellow; but I had no notion that the evil was so general as you appear to have found it. The subject is of such vital importance to photographers, that I intend drawing the attention of that friend to what you have done."

I am indebted to Mr. Osborne for bringing our researches to the notice of his friends at home and abroad, who have contributed interesting articles and valuable information on the subject to the Philadelphia Photographer, (October, 1866,) the London Photographic News, (August 2, 1866,) the London Photographic Journal (Aug. 15, 1866,) and the Photographische Mittheilungen (Sept. 1866).

It may seem singular that so long an experience in the window glass business, had not at an earlier period drawn my attention to the subject of this article. But my experience is not singular. In conversation with many glaziers and glass dealers, I have seldom found one who was aware of the great change of color effected by sunlight. Few have supposed that specimens were to be found in any other windows in our city, than those on Beacon street facing Boston Common and the south, and exposed to the full force of the sun's rays. But having my attention now particularly directed to the subject, I never pass a window without detecting where any considerable change has been effected. I have found them in all portions of the city, and most generally in those positions which face the east and south. The color is most easily detected, when the glass has been ground or enamelled, or where a white window curtain forms a good contrasting back ground. Many people suppose that the very distinctly marked purple plate glass in Beacon st. was imported of this color, and that it is now no longer made; and hence the reason why the windows looked like checkerboards, when broken lights were replaced by those of the usual light greenish color of plate glass.

On this point I have convinced many who had held contrary views, by showing pieces from which the putty on the edges has been removed, and displaying beneath the original color. When the putty covered the glass, the sun's rays could not reach it, and the color was unchanged. Such specimens are quite interesting. I have had many conversations with old glaziers, dealers and consumers of glass, and also with those who stain and enamel it. I have thus gathered specimens of various kinds and colors, and of differing lengths of exposure from old windows. The oldest specimen was one of crown glass set in a church in Lexington, Massachusetts, in 1794, from which the windows were removed in 1846, and since used as covers for hot-beds. The

original color, found by removing the putty from the edges, was a light green, and the present, after seventy-three years exposure, is a purple color. I have never yet met any one who has seen glass in original imported packages, of the purple color made by exposure to sunlight, and until I do, I shall adhere to my opinion, that all purple or rose colored glass which is seen in our city windows, was made so by said exposure. I have very fortunately found an octogenarian, who has furnished me with some glass which was imported, he thinks from some part of Germany, which is of a light green or yellowish green color. The glass was imported more than thirty years ago. Much of that which has been set in his windows facing the south is now purple. An experiment with the original glass, commenced this summer, showed a perceptible change in color in one day, and in two weeks, the change toward purple was so marked that I have no doubt that this color will be distinctly visible in less than a year. If two years were occupied in the erection of the Beacon street houses, or any others in which the plate glass purpled by sunlight is found (as I am informed was the fact in some cases), then the result of the single experiment named above is a sufficient reason for the mistaken belief of many occupants and owners to-day, that the glass was purple when imported. It was probably changed from yellowish green to purple before the houses were finished, and the owners had taken possession.

The action of sunlight which I have spoken of in this article, must not be confounded with that called "rust" or "stain," which is occasioned by exposure to the weather, and manifests itself in two ways; first, by a disintegration and roughening of the surface, sometimes producing all the effects of ground glass; and secondly, by an apparent formation of an infinitesimal coating of oxyd on the surface, on which the play of light gives all the colors of the rainbow, as with the action of light on the infinitesimal grooves of the surface of mother-of-pearl. This is simply surface action, whereas the action of sunlight permeates the whole body of the glass, wherever the rays directly strike it.

The writer of this article, (compiled in the midst of the busy duties of mercantile and official life,) makes no pretension to accurate scientific knowledge, but gives the results of his observations and methodical experiments on a well known phenomenon, in the hopes that they may add some mite to the sum of human knowledge, and may stimulate and aid those who are better versed in scientific studies, to ascertain the causes and exact operations of this interesting power of the sun's rays to paint the products of art, as they do so beautifully and wonderfully the works of nature on the mountain, in the forest and field.

Boston, Mass., July, 1867.

ART. XXXIV.—*Remarks on Prof. Geinitz's views respecting the Upper Paleozoic rocks and Fossils of Southeastern Nebraska;* by F. B. MEEK.

[Concluded from p. 187.]

AFTER preparing the remarks published in the last number of this Journal on the Nebraska fossils figured and discribed by Prof. Geinitz, I had an opportunity, through an incidental connection as Paleontologist, with the Nebraska Geological Survey (in charge of Dr. Hayden, under the direction of the Hon. Commissioner of the General Land Office), to devote about two months to field explorations in the Coal-measures of that region. In order to trace out as fully as possible, the order of succession of the various beds of the whole series, our observations commenced with the Subcarboniferous, and Lower Coal-measure rocks on Desmoines river, Iowa. Over two weeks were thus occupied with Dr. White, the able State Geologist of Iowa, and his efficient assistant, Mr. St. John, accompanied by Dr. Gill of Washington, D. C., in an overland journey from Iowa City, Iowa, westward to Nebraska City, Nebraska.

The remainder of the time was mainly spent with Dr. Hayden and party, in studying the Coal-measure rocks along the Missouri from Omaha, Nebraska, down to Kansas, and in excursions into the interior, including a journey out the Union Pacific Rail Road to its terminus, at that time within five miles of the northeast corner of Colorado. A short time was also devoted to investigating the Coal-measures in the environs of Sumner and Atchison, Kansas, and St. Joseph, Missouri, with Mr. Scarborough, a scientific gentleman of the first mentioned place.*

During these explorations, numerous natural sections, shafts, drifts, quarries, borings, and excavations of various kinds were carefully examined, and large collections of fossils and other specimens obtained. It would of course be out of place here, if I had the authority to do so, to attempt even a general sketch of the results of these explorations.† I am permitted, however, to mention a few of the facts observed, having a bearing on the question in regard to the age of the rocks at and near Nebraska City, referred by Prof. Marcou and Prof. Geinitz to the Permian.

In the first place, it may be well to give a few additional items of information in regard to some of the fossils figured by Prof.

* Our examinations in Iowa and Nebraska, excepting the excursion out the Pacific Rail Road, were made while traveling by land, in wagons or on horse-back, provided with assistants and the necessary fixtures for camping, wherever we wished to stop.

† The facts observed in Iowa will be published in the Report of Dr. White to the proper State authorities; and the results of the observations in Nebraska, in Dr. Hayden's official Report to the Hon. Commissioner of the General Land Office.

Geinitz, from this region, in part mentioned in my remarks published in the last number of the Journal. For convenience, in doing so, I will use the names by which he has designated them, as follows:—

*Cyathaxonia*, taf. v, f. 3. This form from Plattsmouth, compared by Prof. Geinitz, *C. tortuosa* Mich., is the same described by McChesney from the western Coal-measures under the name *C. prolifera*. The other represented by fig. 4, of the same plate from Nebraska City, is probably only a variety of the same. At any rate Dr. Hayden found well-marked examples of the *C. prolifera* in bed B at Nebraska City, that cannot be distinguished on direct comparison with authentic specimens of that species from the typical localities in Illinois.

*Allorisma elegans* King. The shell figured under this name is certainly a distinct species, and not a *variety* of the *elegans*, since a fine series of specimens show it to be *exceedingly* constant in all its characters (which are well represented in Prof. Geinitz's figure), while it differs from that species not only in never attaining one-tenth the size of larger examples of that shell, but in being much narrower and more distinctly truncated behind, as well as in having its umbonal slopes *always* sharply keeled. Its umbones are also more elevated.

*Schizodus Rossicus* de Vern. As nearly as the little shell referred by Prof. Geinitz to this species resembles the published figures of *S. Rossicus*, a direct comparison shows it to be quite as closely allied to *S. curta* of Meek and Worthen, from the Coal-measures of Illinois, and Atchison, Kansas.* It agrees exactly in size, and all other known characters with the *S. curta* excepting that it is a little more compressed, and has slightly less elevated beaks. On comparison with the figures of *S. Rossicus* given in the geology of Russia, the Nebraska shell is found to have its anterior ventral region *constantly* more prominent and rounded, and its posterior margin more distinctly, and more nearly vertically truncated, so as to give more angularity to the posterior ventral extremity, as is well represented by Prof. Geinitz's figures. It is possible these differences may be only due to a want of care in the artist, in drawing the Russian shell; otherwise I should not hesitate to regard the Nebraska form, that from Illinois, and those figured from Russia, as three closely allied, but distinct species. That under consideration is exceedingly constant in all its characters (as shown in a good series of specimens) and exhibits no tendency to the variations of form said to be presented amongst the different individuals of *S. Rossicus*.

* The beds at Atchison, Kansas, hold a lower stratigraphical position than the rocks above the mouth of Platte river, referred by Prof. Marcou to the Mountain limestone.

*Aucella Hausmanni* Goldf. In the last number of this Journal, I expressed the opinion that the form figured under this name, is the same as *Myalina Swallovi*, so common in the western Coal-measures. This conclusion is strengthened by the occurrence of well marked examples of the *S. Swallovi* in the collections before me from Prof. Marcou's bed C, at Nebraska City; while no other similar form was found there or elsewhere in these rocks. On the other hand, the casts figured by Prof. Geinitz (from the Permian of Kansas and not from Nebraska) under the name *Myalina perattenuata*, and which I had supposed to belong to that species, must be the *M. permiana* of Swallow, though they have more attenuate beaks than is common in that species. The two forms, however, are very similar, and in some of their varieties can not be readily distinguished, as has been ascertained from comparison of specimens recently obtained by Dr. Hayden. The typical *M. permiana* does not occur, so far as known, on the Missouri.

*Spirifer laminosus* McCoy. The species figured by Prof. Geinitz under this name, is, as already stated, the common and widely distributed *S. Kentuckensis* of Shumard. In the last number of this Journal, I expressed the opinion that it would probably be found to be a true *Spiriferina*, an opinion I believe also entertained by Dr. Shumard. On recently examining several examples from Nebraska City, and other localities in Nebraska, Iowa and Kansas, I find that they not only show under the microscope the punctate structure, but that they also possess the internal plate of *Spiriferina*. It is an extremely variable shell in the convexity of its valves, as well as in the proportional length of its hinge line. The more ventricose varieties with a short hinge, are sometimes very similar to *S. octoplicata* Sowerby, to which indeed the species has been referred in Stansbury's Salt Lake Report. The individual figured by Prof. Geinitz is a compressed variety (its compression however is *partly* due to accidental pressure) with an extended hinge, and shows a small plication in the mesial sinus not often seen so well developed, though occasionally present. The specimens collected by us at Nebraska City, include all the varieties assumed by this shell at other localities in the Coal-measures.

*Lima retifera* Shumard. Fine specimens of the shell referred to this species by Prof. Geinitz, were obtained by us in the division C at Nebraska City, and they agree well with Dr. Shumard's description. The type specimens first described by Dr. S., it will be remembered, were found in Kansas in the Coal-measures associated with *Fusulina cylindrica* and *Productus Nebrascensis*.

*Stenopora columnaris* Schlot (sp.) Specimens from the divisions B and C at Nebraska City, as well as from various lower

positions in the Coal-measures at other localities, agree more or less nearly with some of the supposed varieties figured under this name by Prof. Geinitz in his work on the German Permian fossils. If that species, however, which according to Prof. G. occurs both in the Permian and Carboniferous of the old world, varies to the extent necessary to include all the forms cited in his synonomy, it would appear difficult to determine the extent of its variations, or its geological range.

*Synocladia virgulacea* (Geinitz, not Phillips; properly *S. biserialis* Swallow). Good examples of this species from division C at Nebraska City, show that the little prominences along the mesial carina of the celluliferous side of the branches, are not generally so elevated as to be properly called even *short* spines. The species, however, differs from *S. virgulacea*, as illustrated and described by King, as already stated, in having properly but two rows of cellules to each branch, instead of from three to five. Nor are these cellules ranged in longitudinal furrows as in *S. virgulacea*. In some instances, in the largest branches, there is an occasional odd cellule near the lateral margins, that cannot be properly regarded as belonging to either of the two rows, but these never form a third or fourth row as shown in *S. virgulacea*. Again, there is always on the Nebraska fossil a single *mesial* longitudinal ridge (usually having minute pores), on the celluliferous side, instead of two, with a mesial row of cells between.

Without going into farther details, I would state that with some two or three exceptions, the lately obtained collections from Nebraska City, and near there include all the species figured by Prof. Geinitz from the beds he refers to the Permian, together with a number of others not collected by Prof. Marcou; and that we now know nearly all these fossils (excepting some seven or eight new species not yet found at any other locality) to be common to these supposed Permian beds and the Coal-measures of Iowa, Illinois, Kansas and Nebraska, where they occur in and beneath, as well as above the very beds referred by Prof. Marcou and Prof. Geinitz, to the Mountain limestone near and above the mouth of Platte river, on the Missouri. In regard to the 7 or 8 new species yet only known from Nebraska City, it may be proper to remark, that with two or three exceptions they are all as nearly allied to Carboniferous as to Permian forms.

In addition to the species figured by Prof. Geinitz, we now know the following other Carboniferous fossils not found here by Prof. Marcou, to occur in the beds he refers to the Upper Dyas at Nebraska City and near there, viz: *Fusulina cylindrica* Fischer, *Terebratula bovidens* Morton, *Orthis carbonaria* Swallow, *Retzia punctulifera* Shumard (=*Terebratula Mormonii* Marcou),*

* Prof. Marcou mentioned finding this at Nebraska City, but Prof. Geinitz does not enumerate it amongst the Nebraska City species, but gives Plattsmouth as the locality. It occurs at both places however.

*Pecten aviculatus* Swallow, (not a true *Pecten*), *Aviculopecten Coxanus* M. & W., *Aviculopecten*, sp. undetermined (common in the Coal-measures of Iowa), and *Pinna peracuta* Shumard; also the following Carboniferous types of fishes, viz: *Ctenoptychius semicircularis* Newberry and Worthen, *Cladodus mortifer* N. & W., *Autliodus* and *Chomatodus* of undetermined species, and another form nearly allied to, or identical with *Deltodus*. We likewise found a fine tooth of *Petalodus destructor* N. & W., so characteristic of the Illinois Coal-measures (referred by Prof. Marcou to the Mountain limestone), in the same beds at Rock-bluff included by him as a part of the Lower Dyas.

It will therefore be seen, that in addition to nearly all of our common Coal-measure *species* of other animal remains, we now know from these supposed Permian rocks of Nebraska and Iowa, the following *genera*, believed to be either exclusively Carboniferous, or not known above the Coal-measures, viz: *Fusulina*, *Erisocrinus*, *Bellerophon*, *Phillipsia*, *Petalodus*, *Cladodus*, *Ctenoptychius*, *Chomatodus*, *Antliodus* and *Cochliodus*; while not a single trace of any peculiarly Permian type of fishes, has ever been found in these rocks.

But it may be proper to mention more precisely the localities and positions at which these Carboniferous types were discovered. In the first place we would state that we found *Fusulina cylindrica* in vast numbers along with nearly all our Coal-measure species at Rock-bluff in the very beds referred by Prof. Marcou to the Lower Dyas. We likewise found this fossil in great numbers 2¾ miles west, and less abundantly at Mr. Morton's place 1¾ west of the Nebraska City landing, associated with the same Coal-measure species, at the elevation of 75 to 80 feet above low water mark of the Missouri; also at Wyoming, 7 miles north, and at Bennett's mill, 3 miles northwest of Nebraska City, all in the same beds referred by Prof. Marcou to the lower part of the Upper Dyas.* *Terebratula bovidens*, *Orthis carbonaria*, *Retzia punctulifera*, *Pinna peracuta*, *Cladodus mortifer*, teeth of *Antliodus* and *Deltodus?* were all found at Nebraska City in division B of Prof. Marcou's section (the last two by Dr. White of Iowa).

The teeth of *Ctenoptychius semicircularis* were found, one in a shaft at Nebraska City, at near the horizon of Prof. Marcou's division B; another at that horizon by Dr. White at Bennett's mill, and another by the same gentleman at Omaha, in beds referred by Prof. M. to the Mountain limestone. We also found it in beds he referred to the latter horizon at Bellevue. The *Chomadotus* was found by Mr. St. John of the Iowa survey, in the so-called Upper Dyas at Bennett's mill. The same *Phillipsia* figured by Prof. Geinitz from Plattsmouth, and a tooth of a *Cochliodus* have

* *Fusulina* and other carb. fossils, also occur in an 18 inch bed of limestone one mile below the outcrop at Nebraska City landing, and at a higher geological horizon.

been found in Iowa by Dr. White, in limestone above the horizon of beds containing the same group of fossils characterizing Prof. Marcou's division C at Nebraska City; while *Pecten aviculatus*, and *Aviculopecten Coxanus*, were found in that bed at the last mentioned locality.

From all the foregoing facts, it will be seen, that I am compelled to dissent from the conclusions adopted by Prof. Geinitz, not only in regard to the relations of many of the Nebraska fossils investigated by him to the European Permian species to which he has referred them, but also respecting the age of the rocks from which they were obtained. Of the various species he identifies with foreign Permian forms, there are, it seems to me, not more than some four or five that are so closely similar that no very satisfactory distinction can be detected, from external characters at least. These are the forms he refers to *Nucula Beyrichi*, *Leda Kazanensis*, *Schizodus Rossicus*, *Avicula spelunearia*,*=(*Pseudomonotis*), and *Pleurophorus Pallasi*. The first four of these are, I acknowledge, very similar to the Permian species to which he has referred them, while the fifth seems to be as nearly like *Pleurophorus costatus*. The fact, however, that we know comparatively little of the hinge and interior of these shells, while they are mainly such forms as often present few reliable external characters for specific distinction, and belong for the most part, to genera in which the species are frequently very similar, must weaken our confidence in these specific identifications, under such circumstances. But when we take into consideration the additional fact, that they can all be identified upon quite as good grounds with forms found far down in beds acknowledged by all to belong the Coal-measures, or which have even at some places been referred by Prof. Marcou to the Mountain limestone, and especially when we bear in mind, the numerous unquestionably Carboniferous types with which they are here directly associated in the beds under consideration, the impropriety of basing important conclusions upon them must be apparent.

It may be urged, however, that with the aid of extensive collections of European Permian species for comparison, Prof. Geinitz has had far better facilities for arriving at correct conclusions, in regard to the relations of all of these Nebraska fossils to foreign forms, than can be commanded here. Granting this to be to a considerable extent true (for I have had for comparison a tolerable collection of the more common European Permian species), I must still contend—with all due deference to his deservedly high standing as a geologist—that his peculiar views in

* The species figured by Prof. Geinitz under this name as elsewhere stated, came from the Permian of Kansas and was not found in Nebraska. He refers to that species, however, specimens from Nebraska City, doubtless the same form we saw at Bennett's mills, and evidently very closely allied to the species *Spelunearia*.

regard to specific and generic distinctions, are such as to materially detract from the value of his paleontological conclusions in a case like that under consideration. The fact that he has unquestionably identified *specifically*, with European forms, several Nebraska fossils belonging to entirely different genera, and in some instances different families, shows conclusively, that if he has kept pace with the recent advances made in conchology and other departments of natural history, he has not, in this instance at least, brought to bear that degree of exactness of discrimination the present state of zoological science shows to be absolutely necessary, before we can hope to arrive at sound conclusions in paleontology.

The necessity for great care in identifying species and genera of shells, has of late years been forcibly illustrated by various anatomical researches, but particularly by the results of the valuable investigations of the lingual dentition of the *Gasteropoda*, made by Loven, Troschel, and others, in Europe, and Dr. Stimpson, Mr. Morse, and others, in this country, by which means forms long regarded as specifically identical have been found to be quite distinct, and so in regard to the genera and higher groups. A case, however, coming more directly home to paleontologists and geologists, is that in which recent microscopical investigations have rendered it probable that a form, until very recently regarded by the highest living authorities as the common *Spirifer cuspidatus* of Sowerby, is not only specifically, but even generically or subgenerically distinct.*

Yet the question may naturally suggest itself, whether, if we admit that only a very few, or even none, of these Nebraska fossils are *absolutely* identical with European Permian *species*, the near affinities of a portion of them to foreign species of that epoch, ought not to be regarded as a sufficient evidence of the contemporaneous age of the rocks from which these were obtained, with those of the Permian of the old world. At a first glance, looking at these Permian types† only, this would certainly seem to be a logical conclusion; and reasoning upon evidence of this kind, Dr. Hayden and the writer actually referred some of these beds on the Missouri to the Permian in 1858, (Trans. Albany Inst., vol. iv.) On afterwards ascertaining, however, that a very large proportion of our most common and characteristic Coal-measure fossils occur in the same beds containing these few Permian types, while the latter, including the so-called *Monotis*, the Bakevellias, *Pleurophorus*, *Schizodus*, &c., are also occasionally met with far below, in unquestionable and acknowledged

* See Proceed. Acad. Nat. Sci. Philad., Dec. 1865, p. 27; this Journ., May, 1867 and Ann. and Mag. Nat. History for July, 1867.

† By Permian types, I mean forms closely allied to, but not necessarily identical with, Permian species.

Coal-measure strata, we were led to doubt the accuracy of our first conclusion.

These doubts were afterwards confirmed, when on going out into the interior of Kansas, we found there an extensive series of strata, in no way separable from the Coal-measures, containing several of these and a few other Permian types, along with nearly all our common Coal-measure fossils, such as *Fusulina cylindrica*, *Productus longispinus?* (=*Productus Wabashensis* N. & P.), *P. punctatus*, *P. costatus*, *P. Nebrascensis* (=*P. horrescens* of Prof. Geintz's list), *Chonetes mucronata*, *Spirifer cameratus*, *S. planaconvexus*, *Syntrilasma hemiplicata*, *Streptorhynchus crenistria*, the so-called *Orthis Missouriensis*, *Athyris subtilita*, *Naticopsis Pricii*, *Euomphalus rugosus** (Hall not Sowerby), species of *Phillipsia*, and *Bellerophon*, *Petalodus Allegheniensis*, and numerous others that might be mentioned. These we found often mingled in the same beds with the few Permian types, and in other instances in beds alternating with those containing the latter. In ascending several hundred feet higher in the series, we observed the Coal-measure forms gradually dropping off until at last, above a certain undefined horizon, with the exception of one or two of the latter, only Permian forms were observed. Although we regarded these upper beds as the true representatives of the Permian, we gave a section of the whole series, down so as to include a considerable thickness of beds below, with lists of fossils, showing the range of the various types, without drawing any line of demarkation, because we were satisfied nature had no where defined any abrupt physical or paleontological break here in the series. We likewise stated that we believed no geologist, studying these rocks without a knowledge of the classification adopted in the old world, would ever have thought of making any important division here between the Permian and the Coal-measures; and that if the intermediate series containing a mingling of the two types of fossils is to be separated at all from the Coal-measures, we would do it only under some such provisional name as the Permo-carboniferous series.

It will be remembered by those who have read Prof. Marcou's paper on the rocks under consideration, (Bull. Soc. Geol. Fr., 2d ser., xxi, p. 132, 1864), that he referred the Nebraska City beds (including those at Bennett's mill and Wyoming) to the upper Dyas; those at Rock-bluff and Plattsmouth to the lower Dyas, and those above the Platte, at Bellvue, St. Mary's, and Omaha City (erroneously printed Omalia City), to the Mountain limestone. The outcrops at Plattsmouth and Rock-bluff, he thought, con-

* Since pointing out the differences between this and *Spirorbis planorbitis*, I observe Prof. Geinitz figures under the latter name, in his Dyas, one form with the greatest concavity apparently on the left, another with it on the right side. The quadrangular form of its whorls, and its flattened periphery, however, clearly separates our shell from both of these.

tained the remains of an "eminently New Red Sandstone fauna, approaching, however, the Carboniferous fauna," (ibid, p. 140.)

After examining the fossils collected by Prof. Marcou from these beds, however, Prof. Geinitz refers 30 of the 36 forms composing this so-called "eminently new red fauna" to Carboniferous species, and thinks these rocks hold the position of the upper division of the Carboniferous limestone, or *Fusulina* limestone of Russia and Spain; while the outcrops of Rock-bluff, he thinks, may be considered an upper marine member of the productive coal formation. It is, therefore, only the Nebraska City beds, and those at Mr. Morton's, Bennett's mill and Wyoming, that he refers to the Dyas.

In not admitting the Plattsmouth and Rock-bluff exposures as belonging to the New Red, Prof. Geinitz certainly corrects a grave error of Prof. Marcou's; but if by the words "Carboniferous, or *Fusulina* limestone," he means to place these rocks on a parallel with any part of the Subcarboniferous or Mountain limestone series, as Prof. Marcou has done those above the mouth of the Platte, he falls into as great an error as that he corrects. The evidence of this statement is, the fact that the group of some thirty odd species of fossils found at these localities is *precisely* that characterizing the Coal-measures of Illinois, Iowa, Missouri, and Kansas, and with the exception of four or five species generally considered common to our Coal-measures and the Mountain limestone, they are *all* distinct from the fossils found in our Carboniferous limestones below the Millstone grit.* In addition to this, they are, with three or four exceptions, now known *all* to occur at Nebraska City, Bennett's mills, and Wyoming, in the very beds Prof. Geinitz considers Upper Dyas, along with other Coal-measure species.

It is probable Prof. Geinitz was mainly led to refer the Plattsmouth rocks to the horizon of the *Fusulina* limestone of Russia and Spain, by the occurrence in them of numerous *Fusulina*, and, as he terms it, "the leading genus *Phillipsia*;" since he acknowledges that a large proportion of the fossils found there also occur in the rock he refers to the Dyas. He was, therefore, evidently not aware of the fact that with nearly *all* of the Plattsmouth fossils, countless millions of *Fusulina* also occur in the Rock-bluff section, placed by him in the Coal-measures; as well as (excepting so far as regards the *numbers* of *Fusulina*) in the

* The following is a list of species known to occur in the Plattsmouth rocks, viz: *Fusulina cylindrica* (in great numbers), *Zeacrinus mucrospinus?*, *Cyathocrinus hemisphericus*, *Productus semireticulatus*, *P. Nebrascensis*, *P. costatus*, *P. Prattenianus*, *P. longispinus?* *P. punctatus*, *Chonetes mucronatus*, *Streptorhynchus crenistria*, *Syntrilasma hemiplicata*, *Meekella striatocostata*, *Athyris subtilita*, *Rhynchonella Utah*, *Retzia punctulifera*, *Spirifer cameratus*, *Spirifer planoconvexus*, *Sp. lineatus?*, *Spiriferina Kentuckensis*, *Myalina subquadrata*, *M. ampla?*, *Pecten (??) aviculatus*, *Aviculopecten occidentalis*, *Pinna peracuta*, *Allorisma subcuneata*, *Bellerophon carbonaria*, *Euomphalus rugosus*, *Nautilus Illinoisensis?*, *Phillipsia* undet. sp.

same beds he and Prof. Marcou include as the inferior member of the Upper Dyas near Nebraska City, at Wyoming and at Bennett's mill. He also ignores the fact, that Prof. Marcou mentions seeing in the Plattsmouth beds, a specimen of the so-called *Monotis** (*Pseudomonotis*), one of the most important types relied upon to prove the divison C, at Nebraska City, a part of the Dyas.† Nor does he appear to duly appreciate the fact that there is no *one* limestone in this country, that can be properly termed "the *Fusulina limestone*," for we have numerous *Fusulina* limestones, at various horizons through the whole Coal-measures of Iowa, Missouri, Nebraska and Kansas; while Dr. White finds it and the genus *Phillipsia*, in Iowa, above beds containing the same groups of fossils characterizing the division C at Nebraska City, referred by Prof. Marcou to the Upper Dyas.

Again, in speaking of the Rock-bluff beds as a "*marine* member of the upper productive Coal-measures," Prof. Geinitz seems not to be aware of the fact, that the whole of our western Coal-measures abound in marine fossils, there being no member of our entire Paleozoic series containing a greater profusion of marine types of fossils than the Coal-measures of Nebraska, Kansas, Iowa, Missouri, Illinois, Kentucky, &c. Had he fully understood all of these facts, and the true relations to each other, and to the other Carboniferous rocks in this country, of the several outcrops from which the fossils submitted to him were obtained, there can be no doubt whatever, but he would have arrived at different conclusions from those adopted by him, respecting the age of these rocks, if not in several instances respecting the specific relations of the fossils themselves, to European Permian forms.

After a thorough revision of the whole subject, and a personal examination of all of the exposures mentioned by Prof. Marcou, and numerous others in Iowa, Nebraska and Kansas, not visited by him; as well as after a careful study of extensive additional collections of fossils from these rocks over wide areas, I have no hesitation in reasserting, that all the rocks above the mouth of Platte river referred by Prof. Marcou to the Mountain limestone, and those of Plattsmouth and Rock-bluff placed by him as Lower Dyas, and by Prof. Geinitz, in part on the horizon of the Upper member of the Mountain limestone, and in part in the Upper Coal-measures, as well as those by both of them referred to the Upper Dyas at Wyoming and Bennett's mill and Nebraska City, with *possibly* the exception of divisions C and D at the latter place, belong to the horizon of the Upper Coal-measures. The only point in regard to which there can be any reasonable doubt is, whether the divisions C and D at Nebraska City, belong more prop-

* Bull. Soc. Geol. Fr., II, xxi, 139.

† It is well known to occur at even much lower horizons in Kansas.

erly to the horizon of the rocks Dr. Hayden and I termed Permo-carboniferous in Kansas, or to the Coal-measures proper. Or, whether in case it is decided that we *must* draw an arbitrary line somewhere in this region, directly between the Coal-measures and Permian, it may not be thought most consonant with the range of types here to bring down this line, in spite, so to speak, of the various acknowledged Carboniferous forms found in these beds, so as to include the divisions C and D in the Permian.

The great objection however, to the adoption of the latter conclusion, is not only the occurrence of so many unquestionable Carboniferous species in the bed C, at Nebraska City, but the fact that nearly the whole group of fossils found in this bed C at that place, including most of the Permian types, such as the so-called *Avicula speluncaria*, *A. pinnaeformis*, *Schizodus*, *Bakevellia*, *Pleurophorus*, *Leda*, *Nucula*, *Cythere*, &c., also occur in Iowa, beneath others containing nearly all of our most common and characteristic Upper Coal-measure types, and indeed beneath heavy beds of limestone, agreeing in lithological characters, and containing the same groups of fossils found in those on the Missouri referred by Prof. Marcou to the Mountain limestone, as has already been determined by Dr. White (see this Journal, July, 1867, p. 28.)* During my late excursion to the west I had the pleasure of visiting, with that gentleman, some of these localities in Iowa. At one place in Union county, we found directly overlying a bed containing the fossils characterizing division C at Nebraska City, a black fissile shale, containing several specimens of *Aviculopecten rectilaterrea* (*Avicula rectalaterarea* Cox), a species which in Kentucky characterizes the horizon of the ninth coal bed of that State. Immediately above this black shale, in a decomposing limestone with marly partings, we found *Fusulina cylindrica* Fischer, *Spirifer cameratus* Morton, *Spirifer Urii* Flem., *S. planoconvexus* and *Spiriferina Kentuckensis* Shumard, *Orthis carbonaria* Swallow, *Productus Nebrascensis* Owen, *P. longispinus* Sowerby?, *Chonetes Verneuiliana* N. & P., *Streptorhynchus crenistriata*, *Naticopsis Wheeleri* (=*Littorina Wheeleri* Swallow, a species scarcely distinguishable from *Natica mariæ* M. V. & K., from the Carboniferous rocks of Russia), and the same little *Phillipsia* figured by Prof. Geinitz from Plattsmouth.

At other places in the same region in Iowa, Dr. White has found in the limestones and other beds holding a still higher position, nearly all of the above fossils, and many other Carboniferous types, such as *Meekella striato-costata* (*Plicatula striato-costata* Cox), *Myalina subquadrata* Shumard, *Productus costatus*, *Athyris subtilita*, and numerous *Fusulina*, with teeth of *Cochlio-*

* It is also well known that in Kansas, beds containing a similar mingling of Permian and Carboniferous types of fossils alternate with others containing almost exclusively Carboniferous forms, through a considerable thickness of strata.

*dus*, &c. Indeed, Dr. White has already shown that the beds in Iowa, containing the group of fossils found in the division C, at Nebraska City, hold a position about the middle of the Upper Coal-measures in that State (see this Journal for July, 1867.)

I may also add, that our examinations through Iowa, fully and completely confirm Dr. White's statement, that no Subcarboniferous rocks are met with after leaving the outcrops seen along the Desmoines river, in going westward all the way to the Missouri nor along the Missouri, in that State; all this intermediate country being occupied by Coal-measures, excepting some insignificant patches of Cretaceous sandstone. I am aware Prof. Marcou has expressed the opinion that all of the Coal-measures of Iowa, Missouri, Illinois, &c., really belong to the horizon of the Mountain limestone. I can only say, however, that this is done in the face of the indisputable facts, that the fossils of these rocks in Iowa, Nebraska, Kansas and Missouri, differ, as already stated, almost entirely from those of our Subcarboniferous rocks, as every one in this country knows; and agree exactly with what he calls an "eminently new red fauna" at Plattsmouth, while the Coal-measures of Illinois, containing the same fauna characterizing those of the other States named, can be traced without interruption to the southern boundaries of that State, and also into Kentucky, where they are separated from the Subcarboniferous rocks, by from fifty to three hundred or more feet of Millstone grit. In addition to this, it is now generally known that Lesquereux has found the flora of the Coal-measures of Illinois, Kentucky and Indiana, to agree with remarkable exactness, so far as the identity and similarity of species are concerned, with that of the true Coal-measures of Europe.

Indeed, so thoroughly have our western Carboniferous rocks been studied of late years, during the progress of the several State geological surveys; and so completely are the order of succession, thickness, characteristic fossils, &c., of their various subdivisions known, that almost any amateur collector in these districts can instantly decide, from a few corals, crinoids or shells, whether they came from a horizon above or below the Millstone grit. In fact, in a very great majority of cases, a single species would be sufficient to decide this question.

In short, all the facts presented by Prof. Geinitz and Prof. Marcou, when explained by what is known in regard to the geological structure of the country in western Iowa, eastern Kansas, and other neighboring districts of the west, exactly coincide with, and confirm the views published by Dr. Hayden and myself in 1858. That is, that there is in this region, a gradual shading off from an upper Coal-measure to a Permian fauna, through a considerable thickness of strata, forming a somewhat intermediate group which we called the Permo-carboniferous

series; also that there is no defined break between this intermediate series, and the Permian above, or the Coal-measures below. Indeed all the phenomena here indicate a gradual change of physical conditions which had probably so nearly approximated those of the Permian in this region, long before the proper close of the Coal-measure period, as to favor the introduction, at certain localities, of some Permian types; while these changes and those following them for a long period of time, running through the interval between the close of the Carboniferous period and the true beginning of the Permian in other parts of the world, where the series seems to be separable into two distinct groups, were not so great as to materially affect the Carboniferous fauna.

Under such circumstances, it must be evident, that all attempts to correlate particular unimportant beds here, with minor subdivisions adopted in Europe, where a different state of things obtained, must necessarily fail; while different opinions will doubtless long exist in regard to the exact horizon in the intermediate series, where the line should be drawn here between the Coal-measures and the Permian. Possibly after much more extensive collections of fossils have been obtained from these rocks, and the vertical range of all of the species has been approximately determined, some more definite conclusions on this point may be arrived at from the percentage of species known to cross certain lines. It is probable, however, that even by this method, the line of division would be found shifting according to the particular parts of the field in which the comparison might be made, for it is evident as we follow the very same beds westward from Iowa and Illinois into Kansas and Nebraska, that the proportion of what would be called Permian types, is found to increase.

In conclusion, I would state, that I hope sometime to have the pleaure of seeing Prof. Geinitz in this country, and of accompanying him to these distant western localities; and although we would doubtless continue to differ upon minor points as to generic and specific distinctions of fossils, I am sure it would not take long to convince so able a geologist as he undoubtedly is, that there is no Mountain limestone within probably more than one thousand feet of the surface on the Missouri in eastern Nebraska, or western Iowa; and that all the rocks referred by Prof. Marcou and himself there to the Subcarboniferous, as well as all they referred to the Permian or Dyas, with *possibly* the exception already alluded to, belong to the Coal-measures.

ART. XXXV.—*Indian Summer;* by JOSEPH E. WILLET, Prof. of Natural Philosophy and Chemistry in Mercer University, Georgia.

A PERIOD of several weeks in Autumn, characterized by smoky atmosphere, equable temperature and cloudless sky, has been known in America as Indian Summer. Several hints as to the cause of this phenomena have been thrown out, but no one of them seems to have been accepted as a sufficient explanation of the facts. The following views have been entertained by the writer for several years, and are presented for the purpose of attracting attention to the subject, with the hope that materials may be collected by observers, the discussion of which may lead to a true theory of Indian Summer.

First, as to the facts.

1. Indian Summer is not confined to North America, but occurs in both hemispheres.

It it so well known in the United States, that no reference need be made to its occurrence here. It is remarkable, however, that it extends on this continent, to very high latitudes.

Sir John Richardson passed the winter of 1848–9 at Fort Confidence, on Great Bear Lake, lat. 66° 54′ N. He remarks,* "with regard to the progress of the seasons, the 'Indian Summer,' as it is called, brought us three weeks of fine weather after our arrival in September."

Kaemtz, in his discussion of the height of the barometer in different seasons, says,† "In the autumn, on the contrary, when the air comes from the south, the south winds predominate; they pour upon the south of Eupope the water with which they are charged, and reach us perfectly dry; hence the beautiful weather, that sometimes prevails in the middle of autumn, and which is known in France under the name of *St. Martin's Summer;* in Germany it is called *the summer of old men*; and in North America, *the Indian Summer.*"

Dr. Livingstone, in his Travels and Researches in South Africa, page 537, when he had arrived at Gonye, lat. 16° 38′ 50″ S., says: "Aug. 22. This is the end of winter. * * * * The whole scenery is lovely, though the atmosphere is murky in consequence of the continuance of the smoky tinge of winter. This peculiar tinge of the atmosphere was observed every winter at Kolobeng," (lat. 24° 30′ S.) "but it was not so observable in Londa as in the south, though I had always considered that it was owing to the extensive burnings of the grass, in which hundreds of miles of pasturage are annually consumed. As the

* Richardson's Arctic Expedition in search of Sir John Franklin, p. 297.
† Complete Course of Meteorology, by L. F. Kaemtz, London, 1845, p. 283.

quantity burned in the north is very much greater than in the south, and the smoky tinge of winter was not observed, some other explanation than these burnings must be sought for. I have sometimes imagined that the lowering of the temperature in winter rendered the vapor in the upper current of air visible and imparted this hazy appearance."

Lieut. J. M. Gilliss, in his very interesting work on Chili,* says, "All through March, and the larger half of April, unexceptionably fine weather lasts, though the atmosphere is less transparent by day than during the other seasons, and copious dews at night show its increasing relative humidity. About the close of the former month, or in the first half of the latter, there are usually from ten to fifteen days when it assumes that peculiar appearance between smoke and dry fog which is so notable as the "Indian Summer" of North America. During its continuance there is scarcely any wind; and, as the temperature after noon rises to summer heat, with its fresh southerly breeze, the air is more enervating than at the latter season. Here the resemblance between the two hemispheres ceases. Unlike the North American "Indian Snmmer," of which, its continuity once broken, there is no return until the following year, the Chilain "verano de San Juan,"† is often interrupted by a renewal of the periodic winds with greater force, or by clouds; and after a day or two, there succeeds another interval, when the air is tranquil and smoky."

In these extracts, we have evidence of Indian Summer in North America, Europe, Africa and South America.

2. Moreover, the indications are, that Indian Summer is a phenomenon of the temperate zone.

I have seen no allusions to it in the writings of travelers in arctic and tropical regions.

As we have seen above, it is distinctly marked in the United States, in Middle Europe, at Santiago in Chili, lat. 33° 26′ 26″ S., and at Kolobeng in South Africa, lat. 24° 30′ S., all within the temperate zone. Sir John Richardson, however, noticed it at lat. 66° 54′ N., just beyond the Arctic Circle, and Dr. Livingstone observed it at Gonye, lat. 16° 38′ 50″ S., about 7° within the torrid zone. The former can scarcely be regarded as an exceptional case, as the observation was made just beyond the Arctic Circle. The latter point is clearly within the torrid zone, but the remarks of Dr. Livingstone show its greater predominance in the temperate. He says "it was observed *every winter* at Kolobeng, (lat. 24° 30′ S.) but it was *not so observable* in Londa" (in which Gonye is situated) "as in the South," and

* The U. S. Naval Astronomical Expedition to the Southern Hemisphere, vol. i. Chile, page 90.

† St. John's Summer.

that too, notwithstanding, the quantity (of grass) burned in the north (toward the equator) is very much greater than in the south" (toward the Antarctic). If the burnings of the grass were the cause of the smoky atmosphere, then the smokiness should have been more apparent toward the equator; whereas the reverse was so strikingly true, that he abandons his previous notions of a connection, between these burnings and the smokiness, of the nature of cause and effect.

3. The season when it appears and the period of continuance of Indian Summer seem, from the above, to be slightly different in different countries.

In North America, it occurs in September, October, or November in different years. It is sometimes confined to one well-defined period of two or three weeks, as at Fort Confidence, in Sept., and Oct., 1848. But more commonly it is extended through one-half or more of the autumn; presenting a series of smoky days, followed by a period of variable weather, to be restored again in full force for a short time, running thus interruptedly through two months or more. Kaemtz describes its season in middle Europe as "the middle of autumn," but says nothing of its duration.

In the southern hemisphere, Dr. Livingstone recorded his single remark of smoky weather on August 22d, which, with the reversed seasons of that hemisphere, corresponds with our February, but goes on to say, that this peculiar tinge of the atmosphere was observed every *winter* at Kolobeng. This would locate the South African Indian Summer in June, July and August, corresponding to our December, January and February, which period is two or three months later than our Indian Summer. Lieut. Gilliss describes the Chilian Indian Summer as extending "through the close of March and the first half of April," which corresponds with our September and October. From his further description above and from the collection of his register below, the season appears to be more marked and decided than with us.

4. Another point worthy of remark, is that there are individual days of smoky weather, distributed through the whole year and undistinguishable from Indian Summer, in any particular except the time of duration. Were they prolonged for a week or two, we should have Indian Summer in nearly every month of the year, and the phenomenon would cease to be regarded as peculiarly autumnal.

At this place, lat. 33° 37′ N., I have noticed for several years, smoky days in every month, excepting about one month in winter and one in summer. The register by Lieut. A. W. Whipple, U. S. A., of Psychrometric and Climatological observations,* on

* Report of Explorations and Surveys for a Railroad Route from the Mississippi River to the Pacific Ocean. Senate. Vol. iv, appendix H.

his survey across the western plains from Ft. Smith, Ark., to San Pedro, Cal., presents the same fact. During the several months mentioned below, the whole period of the survey, observations of "smoky," "smoky atmosphere" and "very smoky" are recorded on the following number of days.

| 1853. | No. of days | 1854. | No. of days |
|---|---|---|---|
| Aug. | 3 | Jan. | 1 |
| Sept. | 6 | Feb. | 1 |
| Oct. | 10 | March | 1 |
| Nov. | 5 | | |
| Dec. | 3 | | |

The register of Lieut. J. M. Gilliss at Santiago in Chili is still more conclusive; for no month, observed during the years 1850–1–2, is without "slightly smoky," "smoky" or "very smoky" days. The number of such days in each month will appear in the following table, which has been collected from the Meteorological Observations, vol. vi.

| | 1850. | 1851. | 1852. |
|---|---|---|---|
| Jan. | 6 | 9 | 23 |
| Feb. | 7 | 8 | 24 |
| March, | 21 | 15 | 26 |
| April, | 18 | 6 | 16 |
| May, | 5 | 7 | 10 |
| June, | 4 | 4 | 4 |
| July, | 5 | 1 | 9 |
| Aug. | 3 | 4 | 9 |
| Sept. | 4 | 3 | 6 |
| Oct. | 2 | 3 | |
| Nov. | 2 | 2 | |
| Dec. | 2 | 6 | |

Of like character with these individual smoky days may be the "dry fog" described by Kaemtz, Meteorology, pp. 469–71, as "common in north and west Germany as well as in Holland" and in other parts of Europe. That of 1783 had remarkable intensity and "presented the following phenomena:—its thickness was such, that in some places objects at the distance of five kilometers (3 miles) could not be distinguished; they sometimes appeared blue or else surrounded with vapor. The sun appeared red, and without brilliancy, and could be gazed at in the middle of the day; at its rising and setting, it disappeared in the haze." The fog appeared on different days in different parts of Europe and Asia—at Copenhagen, May 29th; in France and Italy, from the 16th to the 18th of June; in Norway, June 22d; in Switzerland, June 23d; at Stockholm, June 24th; at Moscow, June 25th; toward the end of June in Syria; and the 1st of July in the Altai. In 1834, Kaemtz noticed others in May, July and August; the one of May seemed to be transferred from place to

place by violent N. E. winds. In these countries (Germany and Holland) the dry fog is coincident with the burning of peat; when the air is dry, the smoke remains suspended in the atmosphere and may be carried away by the winds. The wind always blows from the direction of the peat bogs, when dry fog is manifested; and fogs have frequently been seen coming distinctly from the peat bogs." "The very thick dry fog of 1834 came partly from the combustion of peat, and partly from the fires for which this year was noted." "To the same cause, probably, may be attributed the particular aspect of the air in autumn. In the fine days, when the air is very dry, the air is less transparent; distant objects are not seen distinctly, they appear surrounded by a slight fog." "Can the dry fog of 1783, which was diffused over a great portion of Europe, be attributed to the same cause?" Popular superstition in Europe attributes to this "dry fog" "the disease of smut in corn, and diseases in vegetables generally," and "the predominance of the north winds which then prevail, and they say that it drives away rain and storms, and is a cause of cold."

The above description of "dry fog" accords very well with the appearance of many occasional smoky days in this country, which, if they occurred in autumn, would be styled Indian Summer. Relying upon the description alone, I am inclined to class them together. Kaemtz, also, in the description above, of "the particular aspect of the air in autumn," seems to allude to the German Indian Summer, and thus connects together the phenomena of dry fog and Indian Summer.

So much for the facts, let us now turn to the theory of Indian Summer.

Any theory, to be complete, must equally apply to these occasional smoky days, which are distributed throughout the year; for these present exactly the same characteristics, and are noted by observers, as Lieut. Whipple and Lieut. Gilliss, in precisely the same terms, as the groups of autumnal days, commonly called Indian Summer.

Without alluding to previous theories on the subject, I suggest the following:

1. The smokiness is produced by real smoke, proceeding from the ordinary fires employed in preparing food, etc., or from extraordinary fires in the burning of grass, brushwood, etc. This is an evident and a sufficient cause, and it is unphilosophical to seek for others, until this is shown to be inadequate to the given effect.

Moreover, Kaemtz, as above, plainly ascribes the smokiness of "dry fogs" to the smoke from peat bogs. What is more to the point, Prof. Henry, in allusion to "dry fogs," remarks;*

* Patent Office Report. Agriculture. 1858, pp. 458-9.

"The nature of these fogs is now pretty well understood, and more refined observations, particularly with the microscope, have served to dissipate the mystery in which they were formerly enshrouded. When a portion of the air in which the fog exists is filtered, as it were, through water, and the substance which is retained, is examined by the microscope, it is found to consist of minute fragments, in some cases, of burnt plants, and in others of the ashes of volcanoes." "Samples of substances which have been collected from rain water and examined microscopically by Prof. Schaeffer, of Washington, at the request of the Smithsonian Institution, have been found to consist of portions of plants, which must have come from a great distance, since the species to which they belong are not found in abundance in the localities at which the specimens were obtained. It is highly probable that a portion of the smoke or fog-cloud produced by the burning of one of our western prairies is carried entirely across the eastern portion of the continent to the ocean." In reference to Indian Summer, Prof. Henry remarks, "Though the first announcement of the proposition by some of our earlier meteorologists, that the peculiar condition of the atmosphere known as Indian Summer might be produced by the burning of the prairies, was not thought worthy of any comment, yet the advance of science in revealing the facts I have stated, renders this hypothesis by no means unworthy of attention."

Although these extraordinary fires may furnish the smoke for extraordinary manifestations of smokiness as in "dry fog" or unusually dense Indian Summer, yet I think too little importance has been attached to the smoke from ordinary fires. Immense volumes of smoke ascend daily from these, and it is not improbable that the majority of smoky days derive their smokiness from these ordinary sources.

2. Atmospheric currents, subsiding from higher to lower regions, would produce smokiness by depressing the smoke, and by coming under greater pressure would become relatively dry, and would thus produce relative dryness and equableness of temperature during their continuance.

Every meteorologist has, doubtless desired an indicator or vane for descending currents. Can any be devised more sensitive than smoke? The direction of horizontal currents is constantly determined by the swaying wreaths of smoke from chimneys. If the rising columns of smoke remain suspended in the lower atmosphere and hang like a smoky veil over the whole landscape, why may not the phenomenon be referred to descending currents of air? Why not follow the indications of the vane? If the smoke bends toward the north, east, south, or west, we attribute it to a wind from the opposite quarter. If it

bends toward the earth, why not attribute it to a current from above? Mainly from the fact, that we are less familiar with descending currents, and that from the want of an indicator, we know less of their habitudes.

3. This subsiding of atmospheric currents may occur at any time, when circumstances favor; but it will be most apparent, when a conjunction of circumstances render them continuous through a series of days, as in the autumn.

Hence smoky days may occur in every month of the year, and a succession of them is called Indian Summer—near the autumnal equinox, when the violent disturbing elements of summer heat and winter cold are at a minimum. The vernal equinox would seem to be equally favorable with the autumnal; but, in the former case, a hemisphere cooled by the winter's cold and heating up under the advancing warmth of the season may be less favorable to a stable equilibrium of the atmosphere, than the same hemisphere heated by summer and cooling by radiation during the autumn.

4. Descending currents of air are supposed to occur most in the temperate zones, and Indian Summer seems to be a phenomenon of the same zone.

Kaemtz seems to think that the trade winds return toward the poles as an upper current and settle to the earth about lat. 30° and thence flow as a surface current toward the poles, returning to the equator by some route not well indicated. American meteorologists* think that the atmosphere of a hemisphere is divided into three systems, with upper and lower currents, and with belts of rains or of calms where the systems meet. But all agree as to the descent of the upper currents, whether from the equator or from the poles, to a greater or less extent, over the temperate zone and these may, when other circumstances favor, depress the smoke and produce Indian Summer.

In the above discussion, I have attempted to show that Indian Summer, the occasional smoky days distributed throughout the year, and probably dry fog are similar if not identical phenomena, and attributable to the same cause; that the smokiness is due to ordinary smoke derived from the ordinary or extraordinary fires of a country; that the smoke is held suspended in the lower portions of the atmosphere by descending currents of air; and, finally, that the phenomena seem to prevail most in autumn and in the temperate zones, and the descending currents originate in the subsidence toward the earth of the upper currents from the equator or from the poles.

In conclusion, it is proper to say, that, by examination of the

* See an able paper on the subject by Prof. Henry, Patent Office Report. Agriculture, pp. 471–7. Also Maury's Physical Geography of the Sea. Also a paper by W. Farrel, this Journal, II, xxxi, No. 91.

only complete register, that of Lieut. Gilliss, in my possession, I have not been able to connect the views here presented with the indications of the barometer. This was hardly to be hoped for, from a single register, at one locality.

Indian Summer prevails over a large extent of territory, and its laws must be evolved by the discussion of many registers kept at places distributed over the whole territory. Smokiness is rarely recorded by observers among the phases of the sky, and hence previous registers throw little light upon the subject. Should the attention of observers, hereafter, be directed to this phase, the mass of observations thus obtained may show whether the phenomena are simultaneous or consecutive over a large extent of country; whether the barometer rises or falls, &c.; and may elicit some law favorable or unfavorable to the views above suggested; but which will remove the mystery, which has so long hung around the subject of Indian Summer.

Penfield, Ga., August, 1867.

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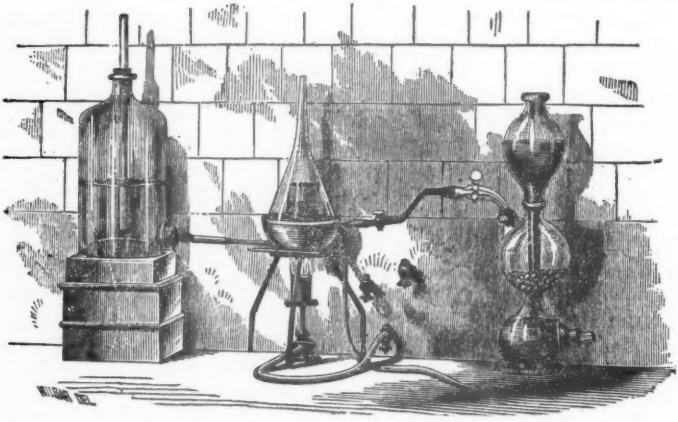
ART. XXXVI.—*A method of determining the amount of Protoxyd of Iron in Silicates not soluble in the ordinary mineral acids;* by JOSIAH P. COOKE, Jr.

THE accurate determination of the amounts of protoxyd and sesquioxyd of iron in siliceous minerals is a point of much importance in mineralogy, and when the silicate can be dissolved by the ordinary mineral acids, this determination presents no great difficulties. But it is very different with the so-called insoluble silicates. In regard to these the problem has never been satisfactorily solved; so that the exact condition of oxydation of the iron in some varieties of the most common species is not with certainty known. Many siliceous minerals which are not perfectly decomposed by the dilute mineral acids in an open vessel, are dissolved after long digestion in a sealed flask, and in a former paper the author described a simple and accurate method of determining the amount of protoxyd of iron in all silicates of this class. The method here described applies chiefly to the silicates, which cannot be thus decomposed and is based on the use of hydrofluoric acid as a mineral solvent. With a very few exceptions all silicates are dissolved after a more or less prolonged digestion in a mixture of sulphuric and hydrofluoric acids, and in this solution the amount of protoxyd of iron can be accurately determined with permanganate of potassa. It is of course essential that the solution should be made out of contact with the air and the difficulty of fulfilling this condition with hydrofluoric acid has probably been the reason why this valuable reagent has not been hitherto used in iron determinations. This difficulty however may be completely overcome

by the apparatus represented in the accompanying figure which, although it may appear complicated at first sight, is really a simple combination of parts, which are familiar in every laboratory.

To the sides of a common copper water bath are attached three tubes as is shown in the figure. The tube on the left connects with a Mariotte's flask by which the water is maintained at a constant level in the bath. The upper tube on the right connects with a carbonic acid gas generator, while the lower tube (connected with the sink by a rubber hose), serves simply as an overflow for the water. On the cover of the water-bath close to the rim is a depressed circular groove, which receives the lip of an inverted glass tunnel. When the apparatus is in



use this groove is kept full of water by the spray from the boiling liquid and thus forms a perfect water joint; but in order to secure this result the bath must be kept nearly full of water and holes for the ready escape of the steam and spray should be provided in the copper rings, which cover the bath and adapt it for vessels of various sizes. It is evident that, by this simple modification of the ordinary water-bath, we can keep our assay surrounded by an atmosphere of steam or of carbonic acid, as may be desirable, during the whole process of digestion, and that too for an indefinite period. Moreover while watching the process through the glass we can either pour in fresh quantities of the solvent, or we can stir up the material, in the vessel within, introducing a tube-tunnel or stirrer through the spout of the covering tunnel.

After the above description the method of making the iron assay will be readily understood. A small amount of the finely

pulverized mineral (from one-half a gram to a gram) is weighed out in a large platinum crucible. Upon this we pour a mixture of dilute sulphuric acid (sp. gr. 1·5) with as little hydrofluoric acid as experience may show is required to dissolve* the mineral stirring up the material with a platinum spatula. The crucible is next transferred to the water bath, the covering tunnel put in place, water poured into the groove, the interior filled with carbonic acid from the generator and the gas lamp lighted. As soon as the water boils, the connection with the generator is closed, and if the water level has been properly adjusted, the apparatus will take care of itself, the groove will be kept full of water and the interior of the tunnel full of steam. If the materials cake on the bottom of the crucible,—as is not unfrequently the case when a large amount of insoluble sulphate is formed,—the lamp may be removed, the apparatus again filled with carbonic acid, and the contents of the crucible stirred up as above described. A stout platinum wire about two inches long, cemented before the blowpipe to the end of a glass tube, makes an excellent stirring rod, and after using it any adhering material can easily be washed back into the crucible by directing the jet from the wash bottle down the throat of the covering tunnel. The lamp may then be replaced, the current of carbonic acid interrupted and the process of digestion continued. When the decomposition is complete the current of carbonic acid gas is reëstablished, the lamp extinguished and the air tube of the Mariotte's flask raised until its lower end is above the level of the overflow. A slow current of water is thus caused to flow through the bath, which soon cools down the whole apparatus. The crucible may now be removed, its contents washed into a beaker glass and the solution diluted with pure water until the volume is about 500 $\overline{\text{c. m.}}^3$, when the amount of protoxyd of iron present can be determined with a solution of permanganate of potassa in the usual way. The total amount of iron present being subsequently determined, the relative proportion of the two oxyds is of course well known. In order to show the accuracy of the method and also to prove that the presence of hydrofluoric acid does not exert any appreciable influence on the permanganate solution we subjoin the following results.

The strength of the solution of permanganate was tested with the double sulphate of ammonia and iron. In each case 1·4 grams of the salt were accurately weighed out and dissolved in about 500 $\overline{\text{c. m.}}^3$ of water. To the first two portions sulphuric acid was alone added while to the last two there was also added a very large amount of hydrofluoric acid, four or five times as

* If the mineral contains lead, baryta, strontia or even lime in any considerable quantity, complete solution cannot of course be obtained, but this is unimportant so long as the mineral is wholly decomposed.

much as would be required in any mineral analysis. The results were

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| No. 1, | 1·4 | grams | iron | salt | required | 26·35 | c. m.³ | permanganate. |
| No. 2, | " | " | " | " | " | 26·35 | " | " |
| No. 3, | " | " | " | " | " | 26·4 | " | " |
| No. 4, | " | " | " | " | " | 26·45 | " | " |

From a specimen of very dark green actinolite treated as above described we obtained in three determinations the following results.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| No. 1, | 0·6913 | grams of mineral | required | 14·1 | c. m.³ | permanganate. |
| No. 2, | 0·6640 | " " | " | 13·6 | " | " |
| No. 3, | 0·8910 | " " | " | 18·2 | " | " |

The per centage composition deduced from this is

| | Per cent of FeO. |
|---|---|
| No. 1, | 19·86. |
| No. 2, | 19·95. |
| No. 3, | 19·89. |

In order to test still further the efficiency of our apparatus we have several times dissolved 2 decigrams of iron in dilute sulphuric acid and heated the solution in the bath for more than twelve hours without its undergoing the slightest oxydation.

It is of course essential in this process that both the sulphuric and hydrofluoric acids should be perfectly pure and wholly free from any oxydizing or reducing agents. There is no difficulty in obtaining from the manufacturers pure sulphuric acid, but unfortunately the commercial hydrofluoric acid is apt to be very impure and must be carefully purified by repeated distillation before it is used in this process. The apparatus here described will also be found very useful in the ordinary iron assays and is also applicable in a large number of analytical processes, where it is necessary that the assay should not be exposed to the air. Of course in such cases a glass beaker would take the place of the platinum crucible, as is shown in the figure. Lastly, this method of heating in an atmosphere of steam will be found very convenient in the many cases where it it is desirable to prevent the evaporation of water during the process. The presence of the steam moreover, prevents to a great degree the escape of the volatile acids; so that in the process above described, the glass covering tunnel is not perceptibly corroded unless the hydrofluoric acid used is very strong.

Cambridge, June 22d, 1867.

## Art. XXXVII.—*The Parks of Colorado.*

[The "San Luis Park" of Colorado, in which the Rio Grande del Norte takes its rise, has recently been described by an anonymous writer, reported on good authority to be Hon. Mr. Gilpin, late Governor of Colorado. This description is so graphic and minute, and exhibits so good an acquaintence with a region which has been but little investigated, that we are led to reprint it from the ephemeral pages in which it has appeared.—Eds.]

*The San Luis Park.*—The San Luis park is readily entered at the extreme north through the Poncho pass, penetrating the Cordillera from the Arkansas river. This park, of elliptical form and immense dimensions, is enveloped between the Cordillera and Sierra Mimbres. It has its extreme northern point between these two Sierras, where they separate by a sharp angle and diverge: the former to the southeast, the latter to the southwest. The latitude of the Poncho pass is 38° 30′, the longitude 106°. It is one hundred and twenty-five miles southwest from Denver, and thirty-seven miles due west from Canyon City.

Emerging from the Poncho pass, the waters begin to gather and form the San Luis river. This flows to the south through a valley of great beauty, which rapidly widens to the right and left. On the east flank the Cordillera ascends abruptly and continuously, without any foot hills, to a sharp, snowy summit; on the west, foot hills and secondary mountains, rising one above the other, entangle the whole space to the Sierra Mimbres.

The Sawatch river has its source on the inner (eastern) flank of the Sierra Mimbres, about sixty miles south of its angle of divergence from the Cordilleras, and by a course nearly east converges toward the lower San Luis river. It enters upon the park by a similar valley. These two valleys expand into one another around this mass of foot hills, fusing into the open park, whose center is here occupied by the San Luis lake, into which the two rivers converge and discharge their waters.

The San Luis lake, extending south from the point of the foot hills, occupies the center of the park for sixty miles, forming a bowl without any outlet to its waters. It is encircled by immense saturated savannas of luxuriant grass. Its water surface expands over this savanna during the season of the melting snows upon the Sierras and shrinks when the season of evaporation returns. From the flanks of the Cordillera on the east, at intervals of six or eight miles asunder, and at very equal distances, fourteen streams, other than the San Luis, descend and converge into the San Luis lake. The belt of sloping plain between the mountains and the lake, traversed by so many parallel streams, bordered by meadows and groves of cottonwood

trees, has from this feature the name "Los Alamosos." It is sixty miles in length and twenty wide. On the opposite (western) side, from the flank of the Sierra Mimbres, similar streams, known as the Sawatch, the Carnero, and the Gareta, descend from the west into the lake.

The confluent streams thus converging into the San Luis lake are nineteen in number. The area thus occupied by this isolated lake and drained into it by its converging affluents, forming distinctly the northern section of the park, and being one-third of its whole surface, is classified under the general name of "Rincon."

Advancing onward to the south, along the west edge of the plains, ten miles from the Gareta, the Rio del Norte issues from its mountain gorge. Its source is in the perpetual snows of the peaks of San Juan, the local name given to this stupendous culmination of the Sierra Mimbres. The Del Norte flows from its extreme source due east one hundred and fifty miles, and having reached the longitudinal middle of the park turns abruptly south, and bisecting the park for perhaps one hundred and fifty miles, passed beyond its rim in its course to the Gulf of Mexico. All the streams descending from the enveloping Sierras (other than the Alamosos) converge into it their tributary waters. On the west come in successively the Pintada, the Rio del Gata, the Rio de la Gara, the Conejos, the San Antonio, and the Pieda. These streams, six or eight miles asunder, parallel, equidistant, fed by the snows of the Sierra Mimbres, have abundant waters, very fertile areas of land, and are all of the very highest order of beauty.

Advancing again from the Rincon, at the eastern edge of the plain along the base of the Cordillera, the prodigious conical mass of the Sierra Blanca protrudes like a vast hemisphere into the plain and blocks the vision to the direct south. The road describes the arc of a semi-circle around its base for thirty miles, and reaches Fort Garland.

In the immediate vicinity of Fort Garland, the three large streams, the Yuta, Sangre de Christo, and the Trenchera, descend from the Cordillera, converge, unite a few miles west, and blending themselves in the Trenchera, flow west twenty-four miles into the Rio del Norte. The line of the snowy Cordillera, hidden behind the bulk of the Sierra Blanca, here again reveals itself pursuing its regular south-southeast course and direction. Fourteen miles south is reached the town of San Luis, upon the Calebra river; seventeen miles further is the town of Costilla, upon the Costilla river; fifteen miles further the town of Rito Colorado is reached; eighteen miles onward is the Arroyo Hondo; (between these is the San Cristova;) from the Arroyo Hondo to Taos is fourteen miles; twenty miles beyond Taos is

the mountain chain whose circle toward the west forms the southern mountain barrier which encloses the San Luis park in that direction.

The San Luis park is then an immense elliptical bowl, the bed of a primeval sea which has been drained; its bottom, smooth as a water surface and concave, is 9,400 square miles in area. It is watered by thirty-five mountain streams, which, descending from the encircling crests of snow, converge, nineteen into the San Luis lake, the rest into the Rio del Norte. An extraordinary symmetry of configuration is its prominent feature. The scenery, everywhere sublime, has the everchanging variety of the kaleidoscope. Entirely around the edge of the plain, and closing the junction of the plain with the mountain foot, runs a smooth glacis, exactly resembling the sea beach, which accompanies the conjunction of the land with the ocean. From this beach rise continuously all around the horizon the great mountains, elevating their heads above the line of perpetual snow. On the eastern side the escarpment of the Cordillera rises rapidly, and is abrupt; on the western side the crest of the Sierra Mimbres is more remote, having the interval filled with ridges, lessening in altitude as they descend to the plain of the park. This continuous shelving flank of the Sierras, completing a perfect amphitheater, has a superficial area equal to that of the level plain which it envelops, and gives to the whole enclosure within the encircling band of snow an area of 18,000 square miles. At an elevation of five or six thousand feet above the plain a level line upon the mountain wall marks the cessation of arborsence, above which naked granite and snow alone are seen. To one who ascends to this elevation at any point, the whole interior of this prodigious amphitheatre is scanned by the eye and swept in at a single glance. Aided by a glass, the smallest objects scattered over the immense elliptical area beneath are discernible through the limpid, brilliant, and translucent atmosphere. Two facts impress themselves upon the senses: the perfect symmetry of configuration in nature and the intense variety in the forms and splendor of the landscape. The colors of the sky and atmosphere are intensely vivid and gorgeous; the dissolving tints of light and shade are forever interchanging; they are as infinite as are the altering angles of the solar rays in their diurnal circuit.

The average elevation of the plain above the sea level is 6,400 feet. The highest peaks have an altitude 16,000 feet above the sea. In the serrated rim of the park, as seen from the plain, projected against the canopy, are discernable seventeen peaks, at very equal distance one from another. Each one differs from all the rest in some peculiarity of shape and position. Each one identifies itself by some striking beauty. From the

snows of each one descends some considerable river, as well within the park as outward down the external mountain bank.

We recognize, therefore, in the San Luis Park an immense elliptical basin enveloping the sources of the Rio Bravo del Norte. It is isolated in the heart of the continent, twelve hundred miles from the sea. It is morticed, as it were, into the midst of the vast mountain bulk, where, rising gradually from the oceans, the highest altitude and amplitude of the continent is attained. This park spreads it plain from 36° to 38° 30′, and is bisected by the 106th meridian. Its greatest length is 210 miles; its greatest width is 100; its aggregate approximate area is 18,000 square miles.

Such being the geographical position, altitude, and peculiar unique configuration, these features suggest the inquiry into parallel peculiarities of meteorology, geology, physical structure, agriculture, mineralogy, and the economy of labor.

The American people have heretofore developed their social system exclusively on the borders of the two oceans, and within the maritime valleys of moderate altitude, having navigation and an atmosphere influenced by the sea. To them, then, the contrast is complete in every feature, in these high and remote altitudes beyond all influence of the ocean, and specially continental.

There is an identity between the "Valley or Park of the City of Mexico" and the San Luis park which ought to be here mentioned. They are similar, twin basins of the great plateau, classifying together and alike in the physical structure of the continent. Mexico is in latitude 20°, longitude 99°, and at 7,500 of altitude. The width of the continent is here 575 miles (from ocean to ocean,) and the divergence of the Cordilleras is 275 miles, which is here the width of the plateau. At the 39° the continent expands to a width of 8,500 miles between the oceans; the Cordilleras have diverged 1,200 miles asunder, and the plateau has widened the same dimensions. In harmony with this great expansion of the continent are all the details of its interior structure. The "Park of the City of Mexico" is but one-tenth in size and grandeur as compared and contrasted with the San Luis park. Of identical anatomy, the former is a pigmy, the latter a giant. The similtude as component parts of the mountain anatomy is in all respects absolute, as is also true of the other parks, which occupy longitudinally the center of the State of Colorado.

*Meteorology.*—The atmospheric condition of the San Luis park, like its scenery, is one of constant brilliancy, both by day and night, obeying steady laws, yet alternating with a kind of playfully methodical fickleness. There are no prolonged vernal or autumnal seasons. Summer and winter divide the year.

Both are characterized by mildness of temperature. After the autumnal equinox the snows begin to accumulate upon the mountains. After the vernal equinox they dissolve. The formation of light clouds upon the crest of the Sierras is incessant. The meridian sun retains its vitalizing heat around the year; at midnight prevails a corresponding tonic coolness. The clouds are wafted away by the steady atmospheric currents coming from the west. They rarely interrupt the sunshine, but refracting his rays, imbue the canopy with a shining silver light, at once intense and brilliant. The atmosphere and climate are essentially continental, being uninterruptedly salubrious, brilliant, and tonic.

The flanks of the great mountains, bathed by the embrace of these irrigating clouds, are clad with dense forests of pine, fir, spruce, hemlock, aspen, oak, cedar, pinon, and a variety of smaller fruit trees and shrubs, which protect the sources of springs and running rivulets. Among the forests alternate mountain meadows of luxuriant and nutritious grasses. The ascending clouds, rarely condensed, furnish little irrigation at the depressed elevation of the plains, which are destitute of timber, but clothed in grass. These delicate grasses, growing rapidly during the annual melting of the snows, cure into hay as the aridity of the atmosphere returns. They form perennial pastures, and supply the winter food of the aboriginal cattle, everywhere indigenous and abundant.

An infinite variety in temper and temperature is suggested as flowing from close juxtaposition of extreme altitudes and depressions; permanent snows, running rivers, and the concentric courses of the mountains and rivers. Storms of rain and wind are neither frequent nor lasting. The air is uniformly dry, having a racy freshness and exhilarating taste. A soothing serenity is the prevailing impression upon those who live perpetually exposed to the seasons. Mud is never anywhere or at any time seen. Moderation and concord appear to result from the presence and contact of elements so various.

The critical conclusions to which a rigid study of nature brings the scrutinizing mind are the reverse of first impressions. The multitudinous variety of nature adjusts itself with a delicate harmony which brings into healthy action all the industrial energies. There is no use for the practice of professional pharmacy. Chronic health and longevity characterize animal life. The envelope of cloud-compelling peaks, the seclusion from the oceans, the rarity of the air inhaled, and the absence of humidity disinfect the earth, the water, and the atmosphere of exexhalations and miasmas. Health, sound and uninterrupted, stimulate and sustain a high tone of mental and physical eneryg. All of these are banished, as it were, by the perpetual brilliancy

and salubrity of the atmosphere and landscape, whose unfailing beauty and tonic taste stimulate and invite the physical and mental energies to perpetual activity.

*Geology and Minerals.*—As a geological basin, the San Luis park is in the highest degree interesting and remarkable. It is found to contain, intermingled and in order, a complete epitome of all the elements of which geological science and research take note. Its intra-mural locality between the primeval crests of the Cordillera, on the east, and the Sierra Mimbres, (here called the "San Juan,") on the west, multiplies this variety indefinitely. These primary Sierras, separated by the park, face one another in full sight, as they rear their flanks from the opposite edges of the concave plain. The successive periods and stupendous forces which have expended themselves to produce what is in sight, and then subsided to an eternal rest, each particularly manifest itself. The comb of the Sierra presents the prodigious plates of primeval porphyry driven up, as the subsoil of a furrow, from the lowest terrestrial crust and protruding their vertical edges toward the sky.

This summit yielding to the corroding forces, presents a wedge toward the canopy; is arranged in peaks resembling the teeth of a saw; is above all arborescence, and is either clad in perpetual snow, or is bald rock.

Against this is lapped perpendicularly the second stratum, less by many thousand feet in altitude, its top forming a brim or bench. This bench, being the rended edge of the erupted stratum, softer than the first and receiving the debris from above, has a deep, fertile soil, a luxuriant alpine vegetation, forests of fir and aspen, and is the highest region of arboresence and vegetable growth.

This is the region of rocks where the metals, especially gold and silver, abound in crevices charged and infused with the richest ores. It is from hence that the gold of the gulches is disintegrated and descends. Here are springs of water and and the sources of rivers. The timber is excellent and the pastures of various grasses luxuriant and inexaustible. Swept by ascending currents of vapor, irrigation is constant. This elevated bench is a permanent characteristic of the mountain flank, continuous as the continent itself; a collossal staircase whose steps are themselves of mountain magnitude. It is here, at these surfaces of contact of the erupted plates of the lowest terrestrial crust, that the thread of the "gold belt" is revealed and found. From this thread, as from a core outward, the precious metals taper in quantity and become diluted in the immensity of the rocks, as a hill of rock salt disappears to the eye, dissolved in the immensity of the ocean.

The top of this continuous bench is undulating, broad, and

occasionally crossed by transverse ridges and the chasms of water-courses. The front flank of this bench forms the stupendous escarpment of the mountains, everywhere lofty and precipitous. It is cut through by innumerable streams, up whose gorges access to the upper regions is attained, and the internal contents, the intestines, as it were, of the rocks are revealed to sight and search.

Forming the pediment of this stupendous mural escarpment is the second brim or bench (being the lowest) in the general mountain descent. Here the approaching elevation of the plain, the increase in size of the streams, the accumulating debris from above, and the increased atmospheric abrasion, all unite to obliterate the angularity of the rocks and impair the striking distinctness of formation. Forests of pine and deciduous trees prevail. The flora and vegetation is abundant and various. The atmospheric irrigation becomes uncertain, and the rocks are covered with soil or the fragments of their own superficial destruction. Immediately following is the broad space occupied by the fusion of the mountain base and the plain gently descending to meet it. Here is a profile infinitely indented and broken; alternately the sloping ridges protrude their ribs into the plain, and the plain advances its valleys between them to receive the streams. This is the region of the placers, where is checked in its descent and lodged beneath the alluvian soil the free gold washed down by torrents from the overhanging summits.

This sketch of the normal structure and configuration of the Cordillera is illustrated by a chequered list of details in its minute elements. The primeval rocks, heated to incandescence, rest in their vertical positions unaltered from their original form; they have been roasted but not liquified. Original strata of limestone and gypsum, uplifted on high but not destroyed, rest upon the summit as a torn hat. Gypsum, limestones, slates, clays, shales, are thus found near the highest summits. The decay of the secondary rocks gives extraordinary fertility to the mountain flanks and to the alluvial bottoms below. Hence the luxuriance of the arborescence, the pastures, and the flora. The altitude of the summits gathers and retains the snows, whose glaciers give birth to innumerable rivers. These gash the precipitous flanks with chasms, up which roads ascend; the composition of the rocks is here revealed; the mysteries of their interior contents are unravelled, and the secretions of nature subjected to the human eye and hand.

Thus, then, erects itself the primeval Cordillera, constructed of horizontal plates, vertically thrown up by stupendous volcanic forces, partially altered or roasted by incandescent heat, but neither destroyed nor recast in form; the secondary rocks are

tossed and scattered high in the upper regions, but are not calcined by flame. The metallic ores are as various as is the variety of the rocks, enriched by heat and exposed by upheaval and corrosion. No lava, no pumice, no obsidien, nothing of melted matter from the plutonic region is seen. This furrowing of the terrestrial crust has alone occupied and exhausted the stupendous volcanic throes of the subterranean world of fire.

*Sierra Mimbres.*—The Sierra Mimbres, forming the western envelope of the park, is not dissimilar to the Cordillera in its origin, composition, and configuration. Rising from the level of the great plateau, it is of inferior bulk and rank. It forms the backbone from whose contrasted flanks descend the waters of the Rio del Norte on the east, and of the Colorado on the west.

Craters of extinct volcanoes are numerous; streams of lava, once liquid, abound; pedrigals of semi-crystalline basalt submerge and cover the valleys into which they have flowed, and over which they have hardened.

This Sierra, then, has a general direction from north to south, corresponding with the 109th meridian. It has all the characteristics in miniature of the Cordillera, but is chequered and interrupted by the escape of subterranean fires, having areas overflowed and buried beneath the erupted current. Where the nascent springs of the Rio del Norte have their birth, the Sierra Mimbres culminate to stupendous peaks of perennial snow, locally named Sierra San Juan.

The concave plain of the San Luis park, begirt by this elliptical zone of the Sierras, thus capped with a ragged fringe of snow projected upward against the canopy, is the receptacle of their converging waters. It is a bowl of vast amplitude, which has for countless ages received and kept the sedimentary settlings of so prodigious a circuit of Sierras, builded up with every variety of form, structure and geological elements elsewhere found to enter into the architecture of nature. Hither descend the currents of water, of the atmosphere, of lava. The rocks rent from the naked pinnacles, tortured by the intense vicissitudes which assail them; the fragments rolled by the perpetual pressure of gravity upon the descending slopes; the sands and soils from the foundations of rocks and clays of every gradation of hardness; the humus of expired forests and annual vegetation; elements carbonized by transient fires; organic decay; all these elements descend, intermingle, and accumulate.

This concave plain is, then, a bowl filled with sedimentary drift, covered with soil and varnished over as it were with vegetation. The northern department or Rincon, closely embraced by the Sierras and occupied by the San Luis lake, is a vast sa-

vanna deposited from the filtration of the waters, highly impregnated with the mountain debris. Beneath this soil is a continuous pavement of peat, which maintains the saturation of the super-soil, and is admirable for fuel.

The middle region of the plain, longitudinally, displays a crater of the most perfect form. The interior pit has a diameter of twenty miles, from the center of which is seen the circumferent wall forming an exact circle, and in height five hundred feet. This wall is a barranca, composed of lava, pumice, calcined lime, metamorphosed sandstone, vitrified rocks, and obsidien. This circumferent barranca is perforated through by the entrance and departure of the Rio del Norte, the Calebra, and the Costilla rivers, which traverse the northern, western and southern edges of the interior. By this and other forces of corrosion this barranca is on these three sides cut into isolated hills, called cerritos, of every fantastic form and of extraordinary beauty of shape and tints. The bottom of the crater has been filled up with the soils resulting from the decay of this variety of material, introduced by the currents of the water and of the atmosphere. It is beveled by these forces to a perfect level; is of the fattest fertility, and drained through the porous formation which underlies it.

From this crater to its southern rim, a distance of sixty-five miles, the park expands over a prodigious pedrigal formed from it in the period of volcanic activity. This pedrigal retains its level, and is perforated by the the Rio del Norte, whose longitudinal course is confined in a profound chasm or cañon, of perpendicular walls of lava, increasing to the depth of 1,200 feet, where it debouches from the jaws of this gigantic flood of lava, near the village of La Joya, in New Mexico. Such are the extraordinary forms and stupendous dimensions with which nature here salutes the eye and astonishes the imagination. The expansion of the lava is all to the south, following the descent toward the sea. Toward the north, repelled by the ascent, are waves demonstrating the defeated effort to climb the mountain base.

Such is an imperfect sketch of this wonderful amphitheater of the Sierras. Its physical structure is infinitely complex, exhibiting all the elements of nature piled in contact, yet set together in order and arranged in harmony; its cloud-compelling Sierras, of stern primeval matter and proportions; its concave basin of fat fertility; its atmosphere of dazzling brilliancy, tonic temperature, and gorgeous tints; its arable and pastoral excellence, grand forests, and multitude of streams; its infinite variety of mines and minerals, embracing the whole catalogue of metals, rocks, clays and fuel; its capacity to produce grain, flax,

wool, hides, vegetables, fruits, meats, poultry, and dairy food; the compact economy of arrangement which blends and interfuses all these varieties; these combine to provoke, stimulate, and reward the taste for physical and mental labor.

Entrance and exit over the rim of the park is everywhere made easy by convenient passes. Roads re-enter upon it from all points of the compass and every portion of the surrounding continent. These are not obstructed at any season. On the north is the Poncho pass, leading to the Upper Arkansas river, and into the south park. On the east, the Mosca and Sangre de Christo passes debouch immediately upon the great plains. On the south is the channel of the Rio del Norte. On the west easy roads diverge to the rivers Chamas, San Juan, and toward Arizona. In the northwest the Cocha-to-pee opens to the great Salt Lake and the Pacific. Convenient thoroughfares and excellent roads converge from all points and diverge with the same facility.

The system of the four parks, extending to the north, indefinitely amplifies and repeats all that characterizes the San Luis park. Smaller in size and less illustrated by variety, each one of the three by itself lingers behind the San Luis, but is an equal ornament in the same family. Their graceful forms, their happy harmony of contact and position, make their aggregated attractions the fascinating charm and glory of the American continent.

The abundance and variety of hot springs of every modulation of temperature is very great. These are also equalled by waters of medicinal virtues. It has been the paradise of the aboriginal stock, elsewhere so abundant and various. Fish, waterfowl, and birds of game and song and brilliant plumage frequent the streams and groves. Animal life is indefinite in quantity and abundantly various.

The atmospheric currents which sweep away every exhalation and all traces of malaria and miasma have an undeviating rotation. These currents are necessarily vertical in direction and equable in force, alternating smoothly as land and sea currents of the tropical islands of the ocean. The silence and serenity of the atmosphere are not ruffled; the changing temperature alone indicates the motion of nature.

All around the elliptical circumference of the plain, following as it were its shore, and bending with the indented base of the mountain, is an uninterrupted road of unparalleled excellence. This circuit is five hundred miles in length, and is graced with a landscape of uninterrupted grandeur, variety and beauty; on the one hand the mountains, on the other hand the concave plain, diversified with groves of alames and volcanic cerritos. At short intervals of five or ten miles asunder are crossed the

swift-running current and fertile meadows of the converging mountain streams. Hot springs mingle their warm water with all these streams, which swarm with delicate fish and waterfowl.

The works of the beaver and otter are everywhere encountered, and water power for machinery is of singularly universal distribution. Agriculture classifies itself into pastoral and arable; the former subsisting on the perennial grasses, the latter upon irrigation everywhere attained by the streams and artificial acequias. This concave configuration and symmetry of structure is remarkably propitious in economy of labor and production, favored by the juxtaposition and variety of material, by the short and easy transport, and by the benignant atmosphere.

The supreme excellence of position, structure, and productions thus grouped within the system of the parks of Colorado, occupying the heart of the continental home of the American people, is conclusively discernable. Here is the focus of the mountains, of the great rivers and of the metals of the continent. The great rivers have here their extreme sources, which interlock and form innumerable and convenient passes from sea to sea. From these they descend smoothly to both oceans by continuous gradations. The parks occupy the line of the fortieth degree, and offer the facilities for a lodgement in force, at the highest altitude, where the highest divide of the continent exists, half way between the trough of the Mississippi and the Pacific shore. Being immediately approachable over the great plains their mines of precious metals are the nearest in the world to the social masses of the American people and to their great commercial cities. Their accessibility is perfect. All the elements of a perfect economy, food, health, geographical position, innumerable mines of the richest ores and every variety, erect, assist, and fortify one another.

The San Luis park has twenty-four thousand population. These people are of the Mexican-American race. Since the conquest of Cortez, A. D. 1520, the Mexican people have acquired and adopted the language, religion, and in modified forms the political and social systems of their European rulers. A taste for seclusion has always characterized the aboriginal masses, heightened by the geographical configuration of their peculiar territory. Upon the plateau elevated seven thousand feet above the oceans, and encased within an uninterrupted barrier of snow, reside nine millions of homogeneous people. An instinctive terror of the ocean, of the torrid heats and malarious atmosphere of the narrow coasts on either sea, perpetually haunts the natives of the plateau. To them navigation is unknown and marine life is abhorrent. The industrial energies of the people always active and elastic, and always recoiling from the sea, have expanded to the north, following the longitudinal direction

of the plateau, of the mountains, and of the great rivers. This column of progress advances from south to north; it has reached and permanently occupies the southern half of the San Luis park.

At the same moment the column of the American people advancing in force across the middle belt of the continent, from east to west, is solidly lodged upon the eastern flank of the Cordillera, and is everywhere entering the parks through the passes. These two American populations, all of the Christian faith, here meet front to front, harmonize, intermarry, and reinvigorate the blended mass with the peculiar domestic accomplishments of each other.

The Mexican contributes his primitive skill, inherited for centuries without change, in the manipulations of pastoral and mining industry, and in the tillage of the soil by artificial irrigation. The American adds to these machinery and the intelligence of expansive progress. The grafted stock has the sap of both. As the coming continental railroad hastens to bind together our people isolated on the seas, a longitudinal railroad of 2,000 miles will unite with this in its middle course, bisecting the Territory, States and cities of 10,000,000 of affiliated people. This will fuse and harmonize the isolated peoples of our continent into one people, in all the relations of commerce, affinity and concord.

San Louis di Calebra, July 5, 1866.

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ART. XXXVIII.—*Contributions to the Mineralogy of Nova Scotia;* by Prof. O. C. MARSH, of Yale College.—No. 1. *Ledererite identical with Gmelinite.*

DURING their first geological excursion to Nova Scotia, in 1827, Dr. C. T. Jackson, and the late Francis Alger, Esq., discovered a mineral at Cape Blomidon which has since been the subject of no little discussion among mineralogists.* These authors apparently regarded it from the first as a new species, but other authorities differed widely as to its true nature. Mr. Brooke of London, after measuring the angles of a crystal, pronounced it to be apatite, a view subsequently controverted by M. Dufrénoy of Paris, while Dr. Torrey of New York considered it nepheline.

Dr. Jackson subsequently described the mineral under the name *Ledererite*, in honor of Baron von Lederer, then Austrian Consul at New York;† and in the same paper Dr. A. A. Hayes, gave the results of an analysis he had made, on which its claims

* Memoirs Am. Acad., vol. i. p. 253.

† This Journal, vol. xxv, p. 78.

to be considered a distinct species were mainly founded. The mineral examined had a specific gravity of 2·169, and its composition, according to this analysis, was as follows:—

| | |
|---|---|
| Silica, | 49·47 |
| Alumina, | 21·48 |
| Lime, | 11·48 |
| Soda, | 3·94 |
| Phosphoric acid, | 3·48 |
| Oxyd of iron, | 0·14 |
| Foreign matter, | ·03 |
| Water, | 8·58 |
| | 98·60 |

The large amount of phosphoric acid, and the small percentage of water obtained, although the determination of the latter was not entirely satisfactory, left the true character of this mineral still a matter of doubt. Berzelius attempted to clear up the difficulty by proposing a formula, based upon Dr. Hayes's analysis, according to which the mineral would consist of three atoms of lime-analcime and one of apatite.*

This view was adopted by Mr. Alger, who suggested also that the crystalline form of the analcime might have been changed to a hexagonal prism by the phosphate of lime.† Rammelsberg proposed to reject the phosphoric acid as an impurity, and with it an amount of lime sufficient to form tribasic phosphate of lime. This would leave a silicate differing from chabazite in having one-third the amount of water, and hence a lime-analcime.‡ The probable identity of Ledererite with Gmelinite appears to have been first suggested by the editors of the London and Edinburgh Philosophical Magazine in 1834;§ and Prof. Shepard, in his Mineralogy of 1835, and Prof. Dana, in his first edition in 1837, place it under that species. This view was subsequently accepted by both Mr. Alger and Dr. Jackson.‖ Finally Descloizeaux, in his Manuel (1862), published measurements of crystals by himself which sustain it.

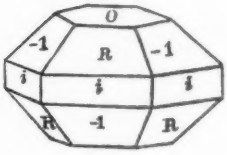
Although the identity of Ledererite and Gmelinite was thus rendered highly probable, the chemical proof was still wanting, and it was very desirable to obtain more of the mineral for further investigation. At the request of Mr. Alger, the writer made a careful search for it at Cape Blomidon during several visits to Nova Scotia, but without success until the summer of 1861, when a number of crystals were found near the original locality, which had long been supposed to be exhausted. This was on the north coast of Cape Blomidon, at a point nearly op-

* Jahresbericht, xiv, 175.
† Alger's Phillipp's Mineralogy, p. 630.
‡ Handwörterbuch, vol. i, p. 387.
§ Vol. iv, p. 394.
‖ Boston Soc. Nat. Hist. Journal vol. v, p. 306.

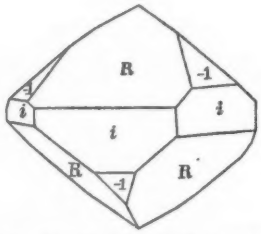
posite Cape Sharp. The crystals were found in geodes in the amygdaloid, accompanied by analcime and quartz, and in most instances implanted upon the latter substance. They were subsequently shown to Mr. Alger, who pronounced them identical with the Ledererite discovered by himself and Dr. Jackson.

The crystals were from one-tenth to one-third of an inch in diameter. Some of them, especially the smallest, were colorless, and nearly transparent; others were yellowish-white or faint salmon-red, and translucent. All were in the form of short hexagonal prisms with pyramidal terminations, as shown in the accompanying figures, that represented in fig. 1 being the typical form. In all the crystals observed the sides of the prisms were marked with horizontal striæ, while the planes of the pyramids were striated parallel to their polar edges. These striæ were in most instances much more distinct than those seen occasionally on crystals of Gmelinite from Irish localities, or from Iceland. There was, moreover, in most of the specimens a tendency toward a rhombohedral form, as seen in the much greater prominence of alternate pyramidal planes, a peculiarity rarely observed hitherto in Gmelinite. In several of the crystals this resulted in the form given in fig. 2.

1.




2.




As the amount of the mineral obtained was sufficient for a chemical examination, the writer, while a student at Heidelberg in 1863, made two analyses of it in the laboratory, and under the direction of Prof. Bunsen.

An attempt was first made to decompose the finely powdered mineral with hydrochloric acid, but without success, although continued over the water-bath for forty-eight hours. A second trial was made in the same way with sulphuric acid, but strange to say, the mineral was apparently little affected. In consequence of this unexpected difficulty, a portion of the mineral which remained was decomposed by hydrofluoric acid, according to Brunner's method, and the constituents, as given below in analysis No. 1 *b*, separated in the usual manner. A third portion of the mineral was first used for a determination of

the water, as given in No. 1*a*, and then fused with carbonate of soda, and its silica separated. A portion of the same mineral, but from a neighboring locality on Cape Blomidon, was also decomposed by fusion with carbonate of soda, and its composition, as given in analysis No. 2, determined in accordance with the usual methods. The amount employed in each analysis was one gram. The specific gravity of the mineral used in No. 1, was 2·108; in No. 2, 2·099, and the hardness in each case was about 4·5. The other physical, and the pyrognostic characters of the mineral, corresponded essentially with those observed in typical Gmelinite. The results obtained in the analyses were as follows:—

| | 1. | | 2. |
|---|---|---|---|
| | *a* | *b* | |
| Silica, | 53·71 | .... | 51·32 |
| Alumina, | | 17·63 | 18·45 |
| Lime, | | 6·52 | 6·40 |
| Potash, | | ·80 | by loss, 3·48 |
| Soda, | | 3·10 | |
| Phosphoric acid, | | trace | .... |
| Water, | 17·98 | .... | 20·35 |
| | | 99·74 | 100.00 |

On comparing these results with those obtained by Dr. Hayes in his analysis, the only one previously made of Ledererite, it will be seen that they differ widely in respect to the amount of phosphoric acid and water—the two important points, in fact, which had occasioned discussion as to the nature of the mineral. It should perhaps, be added that in consequence of this discussion, special precautions were taken to guard against error in determining these substances. The small amount of material at command, rendered it impossible to repeat the analyses; but the results of those completed make clearly evident, what has long been suspected, that the phosphoric acid, found by Mr. Hayes, must be regarded as an impurity, and that Ledererite has essentially the same amount of water as Gmelinite, and hence is identical with that species. The evidence of this identity becomes still more apparent on comparing the composition of the Cape Blomidon mineral, deduced indirectly from a calculation of its constituents as given below, with the results obtained in analyses of typical Gmelinite.

The excess of silica obtained, especially in the first analysis, taken in connection with the remarkable difficulty of decomposition, naturally suggested the presence of impurities in the mineral; and, on examining with the microscope some fragments of a nearly colorless crystal, a quantity of minute crys-

tals of quartz disseminated through the mass were detected. Several other crystals from the same locality were examined, and all found to contain quartz. This discovery clearly explained the large amount of silica obtained in analyzing the mineral, and also, perhaps, its resistance to decomposition.*

If, now, the results obtained in the above analyses be viewed in the light of this discovery, it is evident that the true composition of the mineral can only be ascertained from them by rejecting the quartz. Assuming, then, that the excess of silica in the substance analyzed was due to quartz,—of which, indeed, the microscopical examination afforded good evidence—and calculating from analysis No. 1, first the oxygen ratios respectively of the protoxyd bases, alumina, silica and water, they are found to be, 2·78 : 8·24 : 28·64 : 15·95, or very nearly 1 : 3 : $10\frac{1}{3}$ : 6. As the oxygen of the bases should have to that of the silica the ratio of 1 : 2, all of the latter in excess must belong to the quartz. This would give 12·37 per cent for the amount of quartz in the mineral examined. Deducting this from the quantity of silica obtained, there remains but 41·34 of this substance for combination with the bases, and 87·37 for the sum of the constituents of the mineral itself. By calculating the percentage of these various constituents on the basis of the sum total of the first analysis, it becomes evident that the real composition of Ledererite, thus determined, is as follows :—

| | |
|---|---|
| Silica, | 47·19 |
| Alumina, | 20·13 |
| Lime, | 7·44 |
| Potash, | ·91 |
| Soda, | 3·54 |
| Water, | 20·53 |
| | 99·74 |

These results give the oxygen ratio of 1 : 3 : 8 : 6, and indicate for the mineral the formula $(\frac{1}{3}\dot{N}a+\frac{2}{3}\dot{C}a)\ddot{S}i+\ddot{A}l\ddot{S}i^3+6\dot{H}$, thus clearly establishing its identity with Gmelinite. In chemical consitution it differs from the normal Gmelinite only in having a considerable part of the soda replaced by lime, resembling in this respect the variety from Antrim, Ireland, analyzed by Connell.†

The fact that crystals of this Gmelinite from Cape Blomidon contained 12·37 per cent of silica as an impurity is a very important one, not merely in its bearing on the paragenesis of minerals, but especially for the explanation it suggests of many

* Prof. Bunsen informed the writer that he once experienced a similar difficulty in analyzing a specimen of Chabazite, but made no special examination for impurities.

† Edin. Phil. Jour., xxiv, 362.

difficulties hitherto experienced in reconciling the results of analyses, particularly of silicates. On this point M. Lechartier of Paris has recently published some interesting facts, relating especially to the impurities detected in staurotide.*

New Haven, Oct. 10th, 1867.

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ART. XXXIX.—*Notes on Fossils recently obtained from the Laurentian Rocks of Canada, and on objections to the organic nature of Eozoon;* by J. W. DAWSON, LL.D., F.R.S., F.G.S., *with Notes* by W. B. CARPENTER, M.D., F.R.S.

I. *Specimen of Eozoon from Tudor, C. W.*—This very interesting specimen, submitted to me for examination by Sir W. E. Logan, is, in my opinion, of great importance, as furnishing a conclusive answer to all those objections to the organic nature of *Eozoon* which have been founded on comparisons of its structures with the forms of fibrous, dendritic, or concretionary minerals,—objections which, however plausible in the case of highly crystalline rocks, in which organic remains may be simulated by merely mineral appearances readily confounded with them, are wholly inapplicable to the present specimen.

a. *General Appearance.*—The fossil is of a clavate form, six and a half inches in length, and about four inches broad. It is contained in a slab of dark-colored, coarse, laminated limestone, holding sand, scales of mica, and minute grains and fibers of carbonaceous matter. The surface of the slab shows a weathered section of the fossil; and the thickness remaining in the matrix is scarcely two lines, at least in the part exposed. The septa, or plates of the fossil, are in the state of white carbonate of lime, which shows their form and arrangement very distinctly, in contrast to the dark stone filling the chambers. The specimen lies flat in the plane of stratification, and has probably suffered some compression. Its septa are convex toward the broad end, and somewhat undulating. In some places they are continuous halfway across the specimen; in other places they divide and reunite at short distances. A few transverse plates, or connecting columns, are visible; and there are also a number of small veins or cracks passing nearly at right angles to the septa, and filled with carbonate of lime, similar in general appearance to the septa themselves.

On one side, the outline of the fossil is well preserved. The narrow end, which I regard as the basal portion, is rounded. The outline of the side first bends inward, and then outward, forming a graceful double curve, which extends along the greater

* Bulletin de la Soc. Chimique, May, 1865, p. 375.

part of the length. Above this is an abrupt projection, and then a sudden narrowing; and in the middle of the narrow portion, a part has the chambers obliterated by a white patch of carbonate of lime, below which some of the septa are bent downward in the middle. This is probably an effect of mechanical injury, or of the interference of a calc-spar vein.

With the exception of the upper part above referred to, the septa are seen to curve downward rapidly toward the margin, and to coalesce into a lateral wall, which forms the defined edge or limit of the fossil, and in which there are some indications of lateral orifices opening into the chambers. It is worthy of remark that, in this respect, the present specimen corresponds exactly with that which was originally figured by Sir W. Logan in the 'Geology of Canada,' p. 49, and which is the only other specimen that exhibited the lateral limit of the form.

On the side next the matrix, the septa terminate in blunt edges, and do not coalesce; as if the organism had been attached by that surface, or had been broken before being imbedded.

b. *Microscopic Characters.*—Under the microscope, with a low power, the margins of the septa appear uneven, as if eroded or tending to an acervuline mode of growth; but occasionally the septa show a distinct and regular margin. For the most part merely traces of structure are presented, consisting of small parts of canals, filled with the dark coloring-matter of the limestone. In a few places, however, these appear as distinct bundles, similar to those in the Grenville specimens, but of fine texture.

In a few rare instances only, can I detect, with a higher power, in the margin of some of the septa, traces of the fine tubulation characteristic of the proper chamber-wall of *Eozoon*. For the most part this seems to have been obliterated by the infiltration of the tubuli with colorless carbonate of lime, similar to that of the skeleton.

In comparing the structure of this specimen with that of those found elsewhere, it would appear that the chambers are more continuous, and wider in proportion to the thickness of the septa, and that the canal-system is more delicate and indistinct than usual. In the two former respects the specimens from the Calumet and from Burgess approach that now under consideration more nearly than do those from Grenville and Petite Nation; but it would be easy, even in the latter, to find occasional instances of a proportion of parts similar to that in the present example. General form is of little value as a character in such organisms; and, so far as can be ascertained, this may have been the same in the present specimen and in that originally obtained from the Calumet, while in the specimens from Grenville a massive and aggregative mode of growth seems to have obliterated all distinctness of individual shape. Without additional specimens,

and in the case of creatures so variable as the Foraminifera, it would be rash to decide whether the differences above noticed are of specific value, or depend on age, variability, or state of preservation. For this reason I refer the specimen for the present to *Eozoon Canadense*, merely distinguishing it as the Tudor variety.

From the state of preservation of the fossil, there are no crystalline structures present which can mislead any ordinarily skilful microscopist, except the minute veins of calcareous spar traversing the septa, and the cleavage-planes which have been developed in some portions of the latter.

I would remark that, as it seemed desirable not to injure any more than was absolutely necessary a unique and very valuable specimen, my observations of the microscopic structure have been made on a few slices of small size,—and that, as the microscopic structures are nearly the same in kind with those of specimens figured in former papers, I have not thought it necessary to prepare numerous drawings of them; while the admirable photograph executed for Sir W. E. Logan by Mr. Norman illustrates sufficiently the general form and arrangement of parts.

c. *Concluding Remarks.*—In a letter to Dr. Carpenter, quoted by him in the 'Quarterly Journal of the Geological Society' for August, 1866, p. 228, I referred to the occurrence of *Eozoon* preserved simply in carbonate of lime. The specimens which enabled me to make that statement were obtained at Madoc, near Tudor, this region being one in which the Laurentian rocks of Canada appear to be less highly metamorphosed than is usual. The specimens from Madoc, however, were mere fragments, imbedded in the limestone, and incapable of showing the general form. I may explain, in reference to this, that long practice in the examination of these limestones has enabled me to detect the smallest *Eozoon* when present, and that in this way I had ascertained the existence of this fossil in one of the limestones of Madoc before the discovery of the fine specimen now under consideration.

I am disposed to regard the present specimen as a young individual, broken from its attachment and imbedded in a sandy calcareous mud. Its discovery affords the hope that the comparatively unaltered sediments in which it has been preserved, and which also contain the worm-burrows described by me in the 'Quarterly Journal of the Geological Society' for November,* will hereafter still more largely illustrate the Laurentian fauna.

II. *Specimens from Long Lake and Wentworth.*—Specimens from Long Lake, in the collection of the Geological Survey of Canada, exhibit white crystalline limestone with light-green compact or septariiform† serpentine, and much resemble some of

* Vol. xxii, p. 608.

† I use the term "septariiform" to denote the *curved* appearance so often presented by the Laurentian serpentine.

the serpentine limestones of Grenville. Under the microscope the calcareous matter presents a delicate areolated appearance, without lamination; but it is not an example of acervuline *Eozoon*, but rather of fragments of such a structure, confusedly aggregated together, and having the interstices and cell-cavities filled with serpentine. I have not found in any of these fragments a canal-system similar to that of *Eozoon Canadense*, though there are casts of large stolons, and, under a high power, the calcareous matter shows in many places the peculiar granular or cellular appearance which is one of the characters of the supplemental skeleton of that species. In a few places a tubulated cell wall is preserved, with structure similar to that of *Eozoon Canadense*.

Specimens of Laurentian limestone from Wentworth, in the collection of the Geological Survey, exhibit many rounded siliceous bodies, some of which are apparently grains of sand, or small pebbles; but others, especially when freed from the calcareous matter by a dilute acid, appear as rounded bodies, with rough surfaces, either separate or aggregated in lines or groups, and having minute vermicular processes projecting from their surfaces. At first sight these suggest the idea of spicules; but I think it on the whole more likely that they are casts of cavities and tubes belonging to some calcareous Foraminiferal organism which has disappeared. Similar bodies, found in the limestone of Bavaria, have been described by Gümbel, who interprets them in the same way.* They may also be compared with the siliceous bodies mentioned in a former paper as occurring in the Loganite filling the chambers of specimens of *Eozoon* from Burgess.

III. *Specimens from Madoc.*—I have already referred to fragments of *Eozoon* occurring in the limestone at Madoc, one of which, found several years ago, I did not then venture to describe as a fossil. It projected from the surface of the limestone, being composed of a yellowish dolomite, and looking like a fragment of a thick shell. When sliced, it presents interiorly a crystalline dolomite, limited and separated from the enclosing rock by a thin wall having a granular or porous structure and excavated into rounded recesses in the manner of *Eozoon*. It lies obliquely to the bedding, and evidently represents a hollow flattened calcareous wall filled by infiltration. The limestone which afforded this form was near the beds holding the apparently worm-burrows described in the Society's Journal for November, 1866.

[A thin section of this body, carefully examined microscopically, presents numerous and very characteristic examples of the canal-system of *Eozoon*, exhibiting both the large widely branch-

* Proceedings of Royal Academy of Munich, 1866; Q. J. G. S., vol. xxii, pt. i, p. 185 et seq.

ing systems of canals and the smaller and more penicillate tufts shown in the most perfect of the serpentinous specimens—but with this difference, that the canals, being filled with a material either identical with or very similar to that of the substance in which they are excavated, are so transparent as only to be brought into view by careful management of the light.—W. B. C.]

IV. *Objections to the Organic Nature of Eozoon.*—The discovery of the specimen from Tudor, above described, may appear to render unnecessary any reference to the elaborate attempt made by Profs. King and Rowney to explain the structures of *Eozoon* by a comparison with the forms of fibrous and dendritic minerals,* more especially as Dr. Carpenter has already shown their inaccuracy in many important points. I think, however, that it may serve a useful purpose shortly to point out the more essential respects in which this comparison fails with regard to the Canadian specimens—with the view of relieving the discussion from matters irrelevant to it, and of fixing more exactly the limits of crystalline and organic forms in the serpentine limestones and similar rocks.

The fundamental error of Messrs. King and Rowney arises from defective observation—in failing to distinguish, in the Canadian limestones themselves, between organic and crystalline forms. This is naturally followed by the identification of all these forms, whether mineral or organic, with a variety of purely crystalline arrangements occurring in other rocks, leading to their attaching the term "Eozoonal" to any rock which shows any of the characters, whether mineral or organic, thus arbitrarily attached to the Canadian *Eozoon*. This is obviously a process by which the structure of any fossil might be proved to be a mere *lusus naturæ*.

A notable illustration of this is afforded by their regarding the veins of fibrous serpentine, or chrysotile, which occur in the Canadian specimens, as identical with the tubulated cell-wall of *Eozoon*—although they admit that these veins traverse all the structures indifferently and do not conform to the walls of the chambers. But any microscopist who possesses specimens of *Eozoon* containing these chrysotile veins may readily satisfy himself that, under a high power, they resolve themselves into *prismatic crystals in immediate contact with each other;* whereas, under a similar power, the true cell-wall is seen to consist of *slender, undulating, rounded threads of serpentine, penetrating a matrix of carbonate of lime.* Under polarized light more especially, the difference is conspicuously apparent. It is true that, in many specimens and parts of specimens, the cell-wall of *Eozoon* is badly preserved and fails to show its structure; but in no instance does it present the appearance of chrysotile, or of any

* Quart. Journ. Geol. Soc., vol. xxii, pt. ii, p. 23.

other fibrous mineral, when examined with care under sufficiently high powers. In my original examination of Sir William Logan's specimens from Grenville and the Calumet, I did not detect the finely tubulated cell-wall, which is very imperfectly preserved in those specimens; but the veins of fibrous serpentine were well known to me; and when Dr. Carpenter discovered the tubulation of the cell-wall in the specimens from Petite Nation, I compared this structure with that of these veins, and satisfied myself of its distinctness before acceding to his conclusions on this point.

It would also appear that the radiating and sheaf-like bundles of crystals of tremolite, or similar prismatic minerals, which occur in the Canadian serpentines, and also abound in those of Connemara, have been found with the tubulation of *Eozoon*; but these crystals have no definite relation to the forms of that fossil, and often occur where these are entirely absent; and in any case they are distinguishable by their straight prismatic shape and their angular divergence from each other. Much use has also been made of the amorphous masses of opaque serpentinous matter which appear in some parts of the structure of *Eozoon*. These I regard as, in most cases, simply results of alteration or defective preservation, though they might also arise from the presence of foreign matters in the chambers, or from an incrustation of mineral matter before the final filling up of the cells. Generally their forms are purely inorganic; but in some cases they retain indications of the structures of *Eozoon*.

With reference to the canal-system of *Eozoon*, no value can be attached to loose comparisons of a structure so definite with the forms of dendritic silver and the filaments of moss-agates; still less can any resemblance be established between the canal-system and vermicular crystals of mica. These occur abundantly in some serpentines from the Calumet, and might readily be mistaken for organic forms; but their rhombic or hexagonal outline when seen in cross section, their transverse cleavage-planes, and their want of any definite arrangement or relation to any general organic form are sufficient to undeceive any practised observer. I have not seen specimens of the metaxite from Reichenstein referred to by Messrs. King and Rowney; but it is evident, from the description and figure given of it, that, whether organic or otherwise, it is not similar to the canals of *Eozoon Canadense*. But all these and similar comparisons are evidently worthless when it is considered that they have to account for definite, ramifying, cylindrical forms, penetrating a skeleton or matrix of limestone, which has itself a definite arrangement and structure, and, further, when we find that these forms are represented by substances so diverse as serpentine, pyroxene, limestone, and carbonaceous matter. This is intelli-

gible on the supposition of tubes filled with foreign matters, but not on that of dendritic crystallization.

If all specimens of *Eozoon* were of the acervuline character, the comparisons of the chamber-casts with concretionary granules might have some plausibility. But it is to be observed that the laminated arrangement is the typical one; and the study of the larger specimens, cut under the direction of Sir W. E. Logan, shows that these laminated forms must have grown on certain strata-planes before the deposition of the overlying beds, and that the beds are, in part, composed of the broken fragments of similar laminated structures. Further, much of the apparently acervuline *Eozoon* rock is composed of such broken fragments, the interstices between which should not be confounded with the chambers; while the fact that the serpentine fills such interstices as well as the chambers shows that its arrangement is not concretionary.* Again, these chambers are filled in different specimens with serpentine, pyroxene, loganite, calcareous spar, chondrodite, or even with arenaceous limestone. It is also to be observed that the examination of a number of limestones, other than Canadian, by Messrs. King and Rowney, has obliged them to admit that the laminated forms in combination with the canal-system are "essentially Canadian," and that the only instances of structures clearly resembling the Canadian specimens are afforded by limestones Laurentian in age and in some of which (as, for instance, in those of Bavaria and Scandinavia) Carpenter and Gümbel have actually found the structure of *Eozoon*. The other serpentine-limestones examined (for example, that of Skye) are admitted to fail in essential points of structure; and the only serpentine believed to be of eruptive origin examined by them is confessedly destitute of all semblance of *Eozoon*. Similar results have been attained by the more careful researches of Prof. Gümbel, whose paper is well deserving of study by all who have any doubts on this subject.

In the above remarks I have not referred to the disputed case of the common limestones; but I may state that I have not been able to satisfy myself of the occurence of the structures of *Eozoon* in such specimens as I have had the opportunity to examine.† It is perhaps necessary to add that there exists in Canada abundance of Laurentian limestone which shows no indication of the structures of *Eozoon*. In some cases it is evident that such structures have not been present. In other cases they may have been obliterated by processes of crystallization. As in the case of other fossils, it is only in certain beds,

* I do not include here the "septariiform" structure referred to above, which is common in the Canadian serpentine and has no connection with the forms of the chambers.

† Such Irish specimens of serpentine limestone as I have seen, appear much more highly crystalline than the beds in Canada which contain *Eozoon*.

and in certain parts of those beds, that well-characterized specimens can be found. I may also repeat here that in the original examination of *Eozoon*, in the spring of 1864, I was furnished by Sir W. E. Logan with specimens of all these limestones, and also with serpentine-limestones of Silurian age, and that, while all possible care was taken to compare these with the specimens of *Eozoon*, it was not thought necessary to publish notices of the crystalline and concretionary forms observed, many of which were very curious and might afford materials for other papers of the nature of that criticised in the above remarks.

[The examination of a large number of sections of a specimen of *Eozoon* recently placed in my hands by Sir William Logan, in which the canal system is extraordinarily well preserved, enables me to supply a most unexpected confirmation of Dr. Dawson's statements in regard to the occurrence of dendritic and other forms of this system, which cannot be accounted for by the intrusion of any foreign mineral; for many parts of the calcareous lamellæ in these sections, which, when viewed by ordinary transmitted light, appear quite homogeneous and structureless, are found, when the light is reduced by Collin's "graduating diaphragm," to exhibit a most beautiful development of various forms of canal-system (often resembling those of Dr. Dawson's Madoc specimen, which cross the cleavage-planes of the shell-substance in every direction. Now these parts, when subjected to decalcification, show no trace of canal-system; so that it is obvious, both from their optical and from their chemical reactions, that the substance filling the canals must have been *carbonate of lime*, which has thus completely solidified the shell layer, having been deposited in the canals previously excavated in its interior, just as crystalline carbonate of lime fills up the reticular spaces of the skeleton of Echinodermata fossilized in a calcareous matrix. This fact affords conclusive evidence of *organic structure*, since no conceivable process of crystallization could give origin to dendritic extensions of carbonate of lime disposed on exactly the same crystalline system with the calcite which includes it, the two substances being mineralogically homogeneous, and only structurally distinguishable by the effect of their junction-surfaces on the course of faint rays of light transmitted through them.—W. B. C.]

[The preceding paper was drawn out in part by the observation of Messes. King and Rowney on the Eozoon published in the Quarterly Journal of the Geological Society, vol. xxii, pages 185 to 217, and illustrated by two plates. The following are the *Summary* and *Conclusion* with which the paper of Messrs. King and Rowney closes.—Eds.]

X. *Summary.*—Although zealous advocates at one time for the organic origin of "eozoonal" Ophite, we now, after a prolonged investigation, and after, as we believe, leaving no point unnoticed, feel ourselves under the necessity of totally relinquishing that opinion.

It has been seen (1) that the "chamber-casts" or granules of serpentine are more or less simulated by chondrodite, coccolite, pargasite, &c., also by the bytryoidal configurations common in Permian Magnesian Limestone; (2) that the "intermediate skeleton" is closely represented, both in chemical composition and other conditions, by the matrix of the above and other minerals; (3) that the "proper wall" is structurally identical with the asbestiform layer which frequently invests the grains of chondrodite—that, instead of belonging to the skeleton, as must be the case on the eozoonal view, it is altogether independent of that part, and forms on the contrary, an integral portion of the serpentine constituting the "chamber-casts," under the allomorphic form of chrysotile—and that perfectly genuine specimens of it, completely simulating *casts* of separated nummuline tubules, occur in true fissures of the serpentine granules; (4) that the "canal-system" is analogous to the imbedded crystallizations of native silver and other similarly conditioned minerals, also to the coralloids imbedded in Permian Magnesian Limestone—that its typical Grenville form occurs as metaxite, a chemically identical mineral imbedded in saccharoidal calcite; (5) that the type examples of "casts of stolen-passages" are isolated crystals apparently of pyrosclerite. Furthermore, considering that there has been a complete failure to explain the characters of the so-called internal casts of the "pseudopodial tubules" and other "passages" on the hypothesis of ordinary mechanical or chemical infiltration, also bearing in mind the significant fact that the "intermediate skeleton," in Irish and other varieties of "eozoonal rocks," contains modified examples of the "definite shapes" more or less resembling the crystalline aggregations and prismatic lumps in primary saccharoidal marbles—that "eozoonal" structure is only found in metamorphic rocks belonging to widely separated geological systems, never in their unaltered sedimentary deposits,—taking all these points into consideration, also the arguments and other evidences contained in the present memoir, we feel the conclusion to be fully established, that every one of the specialities which have been diagnosed for "*Eozoon Canadense*" is solely and purely of crystalline origin: in short, we hold, without the least reservation, that, from every available standing point—foraminiferal, mineralogical, chemical, and geological—the opposite view has been shown to be utterly untenable.

XI. *Conclusion.*—From what has been stated in some of the preceding pages, respecting the various chemical changes which "eozoonal" Ophite appears to have undergone, and its mineralogical constituents, we are strongly inclined to believe that it is a pseudomorphic rock, that it existed at one time in the ordinary metamorphic state, perhaps as hornblendic or augitic gneiss, and that it is primarily of sedimentary origin. Whether the same may be concluded of all ophitic rocks is a question on which we cannot offer any opinion—negative, or affirmative. There are some grounds for believing, however, that certain dolerites, generally considered to be of eruptive origin, have become changed into Ophite: and though we have not detected any "eozoonal" structure in an example apparently of the kind, from Monzoni in the Tyrol, which has fallen under our observation, it would not surprise us if this structure were found in ophitic rocks supposed to belong to the eruptive section, considering that the essential mineral (augite) of dolerite contains a large percentage of silicate of lime.

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ART. XL.—*Reply to Mr. Gabb on the Cretaceous rocks of California;* by T. A. CONRAD.

IN the last number of this Journal, Mr. Gabb in some remarks on the age of certain fossils of California, charges me with an "unfair avoidance of a difficulty." I am not aware of either a difficulty or unfairness. The latter refers to the omission of several of his species in my Eocene Check List. This I did for the sufficient reason that I could not be sure whether his typical form was from division A or B of his Cretaceous rocks. I believe that he has in only one instance figured a supposed identical species from each division, and in that instance the shells are not specifically, nor I think even generically related. After such experience, it could hardly be expected that I should trust his judgment in other comparisons.

Mr. Gabb includes the genus *Anchura* Conrad, in division B, but from his statement in his Paleontology it appears not to have been found associated with other fossils, and therefore it is much more likely to be a genus of division A, inasmuch as it has never been found in the Tertiary of any region. He says that the genera *Gyrodes*, *Perrisolax* and *Margaritella* are strictly Cretaceous, which I admit, but his species of *Perrisolax* in division B, is a member of an Eocene genus *Levifusus*, and which is closely related to a Claiborne species. He makes no mention of *Gyrodes* in division B, in his Paleontology, and of *Margaritella* he refers *M. globosa* to division A, and makes no

mention of its occurrence in division B, and *M. crenulata* he refers to no particular division.

It can hardly be reasonable to complain of my omission of *Callianassa* in a Check List devoted exclusively to Testacea, and I doubt the identification of such imperfect specimens of crab's hands as he has figured.

I omitted Ammonites n. s. because it was neither figured nor described, and might be an accidental intruder among Eocene fossils, as so many Cretaceous shells have been found to be. Would it be fair to place the Miocene beds of Cape Fear river, N. C., in the Cretaceous formation on account of the presence of two Cretaceous fossils, *Exogyra costata* and *Cucullæa vulgaris ?*

Mr. Gabb compares his division B to the Maestricht beds, but the latter contain Belemnites, Ammonites, Baculites and Hamites, and according to Lyell, no Tertiary species; whereas Mr. Gabb includes in his division B, the Tertiary genera *Aturia, Venericardia, Dosinia, Pseudoliva* and *Ficus.* His *Dosinia elevata,* however, is a species of a very different Eocene genus, *Dosiniopsis* Conrad. *D. pertenuis* Gabb is either another species of *Dosiniopsis* or a younger specimen of *elevata. D. gyrata* is not stated to occur in division A, and *D. inflata* can hardly be a *Dosinia.* Any evidence so far is wanting to prove the strata in question Cretaceous, and as the group of fossils is so decidedly Tertiary in their forms and some species identical, I am forced to the conclusion of their Eocene origin.

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## Art. XLI.—*Geographical Notices.*

### I. Note on the Diversities in published estimates of the Height of Mount Washington, New Hampshire.

The variation, in statements pretending to approach accuracy, concerning the height of Mt. Washington, has been before remarked, but it may be interesting to see, in numerical order, the principal computations, and estimates given, in English feet, above the level of the sea. They are as follows:—

1. 6,103, as quoted by Prof. Jacob Bigelow in an article presently to be mentioned, from the observations of Capt. Alden Partridge, of Norwich, Vt.

2. 6,128, given on the maps of Colton's General Atlas, edition of 1866; though in the text of the same work the height given is 6,496 feet, we are not told on what authority.

3. 6,225, from barometric observations, made in July, 1816, by a botanical party, comprising Prof. Jacob Bigelow, M. D., of

Harvard College, Dr. Francis Boott, late of London, and Lemuel Shaw, late Chief Justice of Supreme Court of Mass., then all young men. The observations were reduced by Prof. Farrar, of Harvard College. An account by Dr. Bigelow of this visit, is in the New England Journal of Medicine and Surgery, Oct. 1816.

4. 6,226, (or by a series of observations, 6,228,) the height determined by Dr. Chas. T. Jackson, State Geologist, and Messrs. J. D. Whitney, M. B. Williams and Eben Baker, assistants, by barometric and thermometric observations, for a period of 12 hours. See "First Report on Geol. of New Hampshire," 1841, p. 102.

5. 6,238, from barometric observations of Capt. Partridge, in 1821, still retained by some of the Common School Atlases.

6. 6,285, obtained by Prof. Bond, of Cambridge Observatory, with barometer and theodolite. The same result obtained by N. A. Goodwin, C. E., by spirit level. This measurement was adopted by Appleton's New Amer. Cyclopædia, N. Y., 1863.

7. 6,280, from the levelling of Capt. T. J. Cram, Top. Eng., Assist. U. S. Coast Survey, published in Coast Survey Report for 1854. Simultaneous observations, by the barometer, gave 6,206, and by thermo-barometer, boiling point, 6,116.

8. 6,288, Prof. Guyot's final measurement, by barometer, of which a full account is given in this Journal, II, xxxi, 156, March, 1861.

9. 6,290, was a former result obtained by the same, Aug., 1851.

10. 6,293, U. S. Coast Survey, in 1853, (so stated by Prof. Guyot.)

11. 6,428, the result of seven days' observations with a spirit level, Aug. 1820, conducted by Messrs. A. N. Brockett and J. W. Weeks, of Lancaster, N. H., and described in Farmer & Moore's "N. H. Hist. Collections," Apl., 1823, (ii, 97). This measurement is followed in Lippincott's Gazetteer of U. S., Johnston's Physical Atlas, Edinburgh, 1856, the Imperial Gazetteer, Glasgow, 1855, &c.

12. 6,652 is Humboldt's statement (Views of Nature), purporting to follow Lyell. Lyell's "Second Visit to U. S." (1845) gives, however, Dr. Bigelow's measurement.

13. 6,817 (2,078 meters), according to Guibert's Dict. Géographique et Statistique, Paris, 1855.

14. 7,000 and over, McCulloch's Geogr. Dict., edition of 1849.

15. 7,055, and 7,162. In July, 1804, Rev. Manasseh Cutler, LL. D., of Ipswich, Mass., with Dr. W. D. Peck, afterward Prof. of Nat. Hist. at Cambridge, made several barometric observations, which, reduced by Dr. Bowditch (in Mem. Amer. Acad. Arts and Sci., for 1815, vol. iii, pt. 2, p. 326), gave these results.

16. 7,800. Rev. Samuel Williams, LL.D., previously Prof. of Mathematics in Harvard College, in his Hist. of Vermont, published 1794, calculated from the existence of snow on these mountains from Oct. to July, that they nearly reach the line of perpetual congelation, or 7,872 feet. He calls their altitude hardly more than 7,800.

17. 8,000. "The White Mountains are estimated to be at least 8,000 feet high," according to Elements of Useful Knowledge, by Noah Webster, 1812.

18. 9,800, obtained by the first scientific exploring party on record, in July, 1784, from imperfect barometric observations. Of the party were Dr. Cutler, of Ipswich, Rev. D. Little, of Kennebunk, Col. John Whipple, and Rev. Dr. Belknap. The last furnished an account of the trip to the Amer. Philosophical Society, published 1786, in their Transactions (ii, 42).

19. 10,000 and over. Dr. Belknap, however, in his Hist. of New Hampshire, vol. 3, published 1792, expresses himself "persuaded, that whenever the mountain can be measured with the requisite precision, it will be found to *exceed* 10,000 feet, of perpendicular altitude, above the level of the ocean." He adds, that "this peak has lately been distinguished by the name of Mt. Washington." Mr. E. A. Kendall, an Englishman who traveled through Northern U. S. in 1808, records the same as the usual estimate.

20. 11,000 and over, was the height sanctioned by Morse's series of Geographies, at least as late as 1819.

21. 12,729, according to Pres. Dwight's Travels, 1803 (ii, 163.) "It is proverbially asserted," he says, "along the eastern coast, that Mt. Washington is distinctly visible 30 leagues from the shore." He then estimates the distance as at least 140 miles, and adds: "The elevation of this summit, calculating upon its visibility at this distance, and making the proper allowance for the refraction of light, will be 12,729 feet. Another deduction ought, however, to be made for the fact, that, instead of being seen at the surface, it probably is always first perceived at mast head."

22. Above the lower limit of perpetual snow!—so given in a primary geography published in 1859, at New Haven. "The White Mountains have this name because their tops are covered with snow and ice *all the summer*, as well as in the winter."

### II. Notes on Recent Geographical Maps, Books and Intelligence.

*Russian America.*—The recent purchase of this important province by our government, has awakened special attention to its physical characteristics. We have already announced the departure from San Francisco of a scientific party, who are to

engage in the exploration of that comparatively unknown region.

By far the best summary, in English, of what is now known respecting Russian America, may be found in the speech of Hon. Charles Sumner, Chairman of the Committee on Foreign Affairs, delivered in the U. S. Senate, when the treaty of cession was presented to that body (Wash. 1867, 8vo, pp. 48). Appended to the pamphlet is a map, which exhibits not merely the newly acquired Alaska, but also its relations to the East coast of Asia, and the great Behrings sea. This map, which is on the scale of 1: 5,000,000, was prepared at the office of the U. S. Coast Survey, and is separately published.

Senator Sumner, with the varied learning for which he is distinguished, recapitulates the sources of information in European literature respecting Alaska, and then proceeds to make up from them all a monograph of the country, considered under these seven heads; first, government; second, population; third, climate; fourth, vegetation; fifth, minerals; sixth, furs; seventh, fisheries. Our limits only allow us, in this brief way, to call attention to this survey. In respect to the climate, we transcribe a striking tabular statement, compiled at the request of Mr. Sumner, from the archives of the Smithsonian Institution, by one of the collaborators who visited Russian America under the auspices of the telegraph company.

| | Mean Temperature in degrees Fahrenheit. | | | | | Precipitation in Rain or Snow. Depth in inches. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Spring. | Summer. | Autumn. | Winter. | Year. | Spring. | Summer. | Autumn. | Winter. | Year. |
| St. Michales, Russian Amer. Lat. 63° 28′ 45″ North. | 28.75 | 52.25 | 27.00 | 7.00 | 27.48 | | | | | |
| Fort Youkon, Russian Am. Lat. (near) 67°. | 14.22 | 59.67 | 17.37 | 23.80 | 16.92 | | | | | |
| Ikogmut, Russian America. Lat. 61° 47′. | 19.62 | 49.32 | 36.05 | 0.95 | 24.57 | | | | | |
| Sitka, Russian America. Lat. 57° 03′. | 39.65 | 53.37 | 43.80 | 32.30 | 42.12 | 18.32 | 15.75 | 32.10 | 23.77 | 89.94 |
| Puget sound, Wash. Ter. Lat. 47° 07′. | 48.88 | 63.44 | 51.30 | 39.38 | 50.75 | 7.52 | 3.68 | 15.13 | 20.65 | 46.98 |
| Astoria, Oregon. Lat. 40° 11′. | 51.16 | 61.36 | 53.55 | 42.43 | 52.13 | 16.43 | 4.85 | 21.77 | 44.15 | 87.20 |
| San Francisco, California. Lat. 37° 48′. | 55.39 | 58.98 | 58.29 | 50.25 | 55.73 | 6.65 | 0.09 | 2.69 | 13.49 | 22.92 |
| Nain, Labrador. Lat. 57° 10′. | 23.67 | 48.57 | 33.65 | 0.40 | 26.40 | | | | | |
| Montreal, Canada East. Lat. 45° 30′. | 41.20 | 68.53 | 44.93 | 16.40 | 42.77 | 7.66 | 11.20 | 7.42 | .72 | 27.00 |
| Portland, Maine. Lat. 43° 39′ | 40.12 | 63.75 | 45.75 | 21.52 | 42.78 | | | | | |
| Fort Hamilton, New York. Lat 40° 37′. | 47.84 | 71.35 | 55.79 | 32.32 | 51.82 | 11.69 | 11.64 | 9.88 | 10.31 | 43.22 |
| Washington, Dist. of Col. | 54.19 | 73.07 | 58.91 | 33.57 | 53.69 | 10.48 | 10.53 | 10.16 | 10.06 | 41.24 |

It will be seen, from this table, that the winters of Sitka are relatively warm, not differing much from those of Washington, and several degrees warmer than those of New York; but the summers are colder. The mean temperature of winter is 32° 30′, while that of summer is 53° 37′. The Washington winter is 38° 57′; the Washington summer is 73° 07′. These points exhibit the peculiarities of this Alaskan coast—warm winters and cool summers.

*Inter-oceanic Canals and Railroads, between the Atlantic and Pacific Oceans.*—Rear Admiral C. H. Davis, as Superintendent of the National Observatory, prepared last year for the Secretary of the Navy, in pursuance of a resolution of the U. S. Senate, a Report on the means of inter-oceanic communication across the great American Isthmus (Wash. 1867, 8vo., 38 pp. 14 maps). The Report contains a series of important maps and profiles, and among them (in the second edition, March 14, 1867) may be found a very curious copy of a Spanish map of Darien, based on surveys made between 1780 and 1790. All the twenty-six transit projects, including railroads and canals, which have been offered to the world, are briefly characterized by Admiral Davis, important statistical tables are appended, and a bibliographical list of the authorities on the subject is also given. The maps and profiles embody the most important results acquired in the various surveys of Barnard, Squier, Hughes, Trautwine, McDougal, Michler, and others.

Two maps of what is known as the "*North Western Boundary*" between the United States and Great Britain, have just been printed by the Government at Washington. They are compiled under the direction of Archibald Campbell, Commissioner, and John G. Parke, U. S. Eng., Chief Astronomer and Surveyor of the N. W. Boundary Survey.

The country delineated, is that lying between the 110th meridian, the sea coast, and between the parallels of 46° and 49° 30′, N. lat. Thus the basins of the Columbia and Fraser rivers, and Vancouver's Island, etc., are included. The effort has been made to present not merely the original work of the survey, but also the investigations of other British and American explorers. The topography is quite in detail, but is not always satisfactory, especially in the representation of mountains. For example, the marked predominance of Mt. St. Helens, and Mt. Adams, above the adjacent country, would not be inferred from the map. The publication of the accompanying Report of the Commission, is deferred as we learn by a letter of the Commissioner, until the meeting of Congress.

Copies of the *Journal of the Royal Geographical Society of London*, vol. xxxvi, for 1866, have just been received. It contains

more than the usual variety of interesting papers and maps. Among them, we may mention an account, by M. Chandless, of his ascent of the River Purûs, one of the chief tributaries of the Amazon, in 1864 and 1865. He has drawn a map of the river, from his own astronomical observations and measurements. The astronomical data are said to be the first ever ascertained, notwithstanding that there have been four previous surveys of the river. Mr. Chandless also contributes a paper on the river Aquiry, the principal affluent of the river Purûs. For these unaided surveys over a distance of 1,866 miles, the Geographical Society awarded to Mr. Chandless the Victoria gold medal. Two articles, translated from the Russian of M. Veniukof, convey a large amount of interesting matter, respecting the knotty and hitherto unsatisfactory geography of the Bolor Dagh, and the country of the Belors.

Five numbers have reached us of a new "*Dictionnaire de Géographie Ancienne et Moderne*" (Paris, Didot, 1866-7, 8°), designed as a sort of supplement to Brunet's well known "*Manuel du Libraire.*" Though prepared for bibliographers, the work will be of great value to any student of geography or history,—as it gives, in the first part, the modern equivalents of the ancient names of European places, and in the second part, the ancient designations, corresponding to modern French names. The only corresponding work, in common use, is that of Bischoff & Möller, but this new publication promises to be even more convenient and complete. With its help, it will be easy for the ordinary reader to identify, at once, the names of places, referred to by writers in the middle ages, and now recognized with difficulty in the nomenclature of modern maps and lexicons.

Behm's "*Geographisches Jahrbuch,*" (Leipsic, 12°) for 1866, is a valuable manual for ready reference in geographical studies. It is designed to convey, in the first place, geographical statistics respecting all the countries of the globe, arranged not alphabetically, but continent-ally,—including the areas and population of provinces and states, according to the latest local authorities. This part is followed by tables of the principal known heights of mountain-peaks and of lakes, measurements of river basins, and select climatic data. Several short articles on the recent progress of geographical science, by different writers, come next; and the volume is concluded, by a collection of tables, designed to facilitate the transfer of geographical measurements, from the terminology of one country to that of another. A work so useful deserves general encouragement.

From recent numbers of Petermann's Journal we gather the following intelligence.

*The northernmost land of the Globe.*—The publication of Dr. I. I. Hayes's final report on his researches in 1860 and 1861, has given Dr. Petermann occasion to present a series of five maps illustrative of the progress of discovery in the basin north of Baffin's Bay. The first of these shows the base outline of Baffin's Bay as given by Bylot and Baffin in 1616, a rude sketch with scarcely ony details. The second shows the careful coast survey of Ross, two hundred years later, in 1818. Smith's sound is represented as land-locked except on the south. In the third map, Inglefield's passage in 1852 through Smith's sound nearly to 80° N., is exhibited. Then comes a sketch of Dr. Kane's researches extending to Mt. Parry in about lat. 82°, and finally Dr. Hayes's penetration to Cape Union, the most northern point yet attained is about 82° 30′. A full memoir accompanies his maps.

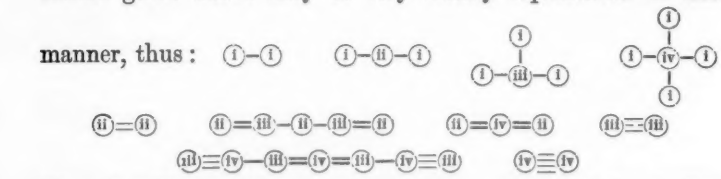
*Marine currents of the North Circumpolar basin.*—The conclusion of an elaborate paper by A. Mühry, presents the following results of his investigations.

"As an outward current, one stream flows from the east and another from the west along the edge of the Polar basin, where in winter a rim of continental ice is formed, and in summer these currents float this ice away. Thus there exists a floating ice ice-girdle, some twenty or thirty geographical miles in breadth, in which the walfishery is pursued. Scoresby did not reach the northern rim, but Parry did and passed over it. The inward current, the gulf stream, has a breadth from the southwest coast of Greenland to the northwest coast of Norway. Both polar streams dip under,—the eastern on the southeast coast of Greenland, the western on the east side Newfoundland, sinking beneath the gulf stream as a counter polar current where the temperatures are related as 0° to 7° and to 12° Reaum. The counter or anti-polar currents of the gulf stream dip under in four places, on the west side of Nova Zembla, Spitzbergen, Iceland and South Greenland, where the temperatures are related as 3° to 0° Reaum. The fact also indicates that along the middle line of the basin a current flows toward the aperture."

*Malden's Island.*—This island, (referred to as a deposit of guano by Prof. J. D. Hague, in this Journal II, xxxiv, p. 242,) has been taken possession of by a mercantile house of Melbourne in the name of the British Government. It belongs to a group of small coral islands, (lat. 4° 15′ S., long. 155° W.), which the U. States had previously claimed, and which was subsequently known as the "American Polynesia."

## Art. XLII.—*On normal and derived Acids;* by George F. Barker.*

The law of saturation by equivalence, introduced into chemistry by Kekulé, determines at once the formula of every possible binary compound.† Assuming that the simple radicals may be divided into four groups, it will be seen that the number of binary compounds is limited to the following ten classes; monads with monads, as $K'Cl'$; with dyads, as $O''H'_2$; with triads, as $Au'''Cl'_3$; and with tetrads, as $Pt^{iv}I'_4$; dyads with dyads, as $Mg''O''$; with triads, as $As'''_2O''_3$; and with tetrads, as $C^{iv}O''_2$; triads, with triads, as $B'''N'''$; and with tetrads, as $Zr^{iv}{}_3N'''_4$; and finally tetrads with tetrads, as $Pt^{iv}Si^{iv}$. The number of atoms therefore, which enter into such compounds, is determined by a very simple mathematical law. On this fact rests the possibility of graphic representation. Of the various methods in use, that of A. Crum Brown, in which the atom is represented by a circle, and its equivalence by projecting lines called bonds or units of attraction, is perhaps the best. As every compound body must be saturated, i. e., have all its bonds engaged, the ten classes given above may be very clearly represented in this manner, thus:



Here it will be noticed, no bonds are exchanged by similar atoms; i. e., those of the same element.

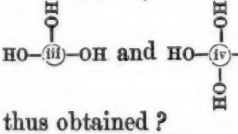
* In this paper, H=1, O=16, S=32, **C**=24, **Al**=55, **Si**=56, etc.

† When two radicals unite together, the number of atoms of each required for mutual saturation, is obtained by dividing the least common multiple of the numbers representing their equivalencies by the equivalence of each. Generally, the number of atoms of each radical is inversely as its equivalence, four triad atoms saturating three tetrads, for example. Atoms thus combined, alternate with each other, the two units of attraction in each exchange, belonging to dissimilar radicals.

When, however, similar atoms unite directly, two units of attraction disappear for each pair of atoms, being occupied in holding these atoms together. Two tetrad atoms thus combined, have therefore an equivalence of six, three such atoms of eight, four of ten, etc. Or, as Kekulé has shown (Lehrbuch, 1861, i, 163), the number of units of attraction left free by the union of any number of carbon atoms is equal to twice the number of such atoms, plus two (=2n+2). C. G. Foster has extended this law to all the poly-equivalent radicals (Watts' Dictionary, i, 1007) giving the formula $E=S-2(n-1)$, in which E indicates the group-equivalence, *n* the number of poly-equivalent atoms, and S the sum of their units of attraction. By this formula, the highest number of hydrogen atoms which can be united with ten carbon atoms for example, is $40-2(10-1)=22$, giving the hydrocarbon $C_{10}H_{22}$. From this a series of lower compounds may be formed, each differing from the next higher, by $H_2$.

If now any of these bonds be left unsatisfied, or in other words, if the chemical edifice represented by the molecule be incomplete, it is evident that the whole structure, whatever its complexity, is capable of entering into combination by its free bond or bonds. Hence in this case, the compound body will act precisely like a simple radical having the same equivalence. Such unsaturated bodies are called compound radicals and their equivalence or combining power is exactly equal to the number of unsatisfied bonds. These compound radicals, therefore, may be used in place of the simple radicals, in the formulas above given; thus forming a new set of compounds, which, since the number of compound radicals possible is almost unlimited, are exceedingly numerous. The compound radicals most in use are those derived from the hydrogen compounds of the different groups of simple radicals, by successive unsaturation. If from the ordinary so-called types, HCl, $H_2O$, $H_3N$, $H_4C$ an atom of hydrogen be removed, there is left $Cl'$, $(HO)'$, $(H_2N)'$, $(H_3C)'$, all monad compound radicals. By continuing the process where it is possible, radicals of higher equivalence are thus produced.

With these facts premised, I pass to the subject of the present paper; i. e., the consideration of the bodies which result from the union of the monad compound radical hydryl $(HO)'$ with the simple radicals. Representing $H_2O$ by Ⓗ–Ⓞ–Ⓗ, hydryl is Ⓗ–Ⓞ–, which may be represented either by a larger circle or by the letters alone, thus HO–. From the principles above stated, we deduce the formulas Ⓘ–OH HO–Ⓘⓘ–OH



HO–Ⓘⓘⓘ–OH and HO–Ⓘⓥ–OH. What is the character of the bodies thus obtained?

A reply to this question becomes possible only by classifying the simple radicals according to their electro-chemical characters. In the method of classification given above, the elements are divided according to the *quantity* of their combining power i. e., to their equivalence; here the division is into positive and negative, according to the *quality* of this combining power. When a *positive* simple radical combines with hydryl, a *base* is produced; when a *negative* simple radical so unites, an *acid* results. If, for example, the vertical columns in the table below, represent the equivalence, increasing from left to right, and the horizontal the electro-chemical character, we may illustrate these statements as follows:—

| | *Monad.* | *Dyad.* | *Triad.* | *Tetrad.* |
|---|---|---|---|---|
| − | $Cl'(HO)$ | $S''(HO)_2$ | $B'''(HO)_3$ | $C^{iv}(HO)_4$ |
| + | $K'(HO)$ | $Ca''(HO)_2$ | $Bi'''(HO)_3$ | $Zr^{iv}(HO)_4$ |

The formulas in the upper row represent well known acids, and those in the lower, as well known bases.

It has been thus far assumed that the equivalence of a radical is invariable. But it seems evident that when one element combines with another in more than one proportion, its combining power must be different in the two cases. Thus in stannic oxyd $SnO_2$ and stannous oxyd SnO; tin is evidently a tetrad in the former case and a dyad in the latter. In all cases, however, the equivalence changes by two, either up or down; it therefore never alters from even to odd or the reverse. A dyad may act as a tetrad or hexad; a monad as a triad, pentad or heptad. Applying this principle now to the compounds of the radicals with hydryl, we notice that the negative radicals vary their equivalence by several stages, forming a series of acids; but that the positive radicals rarely form more than a single series of bases, their equivalence being fixed at a single stage. With negative radicals, we may have for example :—

| *Monad.* | *Dyad.* | *Triad.* | *Tetrad.* |
|---|---|---|---|
| $Cl'(HO)$ | $S''(HO)_2$ | $P'''(HO)_3$ | $Sn^{iv}(HO)_4$ |
| $Cl'''(HO)_3$ | $S^{iv}(HO)_4$ | $P^{v}(HO)_5$ | - - - - - |
| $Cl^{v}(HO)_5$ | $S^{vi}(HO)_6$ | - - - - | - - - - - |
| $Cl^{vii}(HO)_7$ | - - - - | - - - - | - - - - - |

But the only instance of such changes with the positive radicals, is in the case of the perhydrates of the alkaline earths; as $Ba^{iv}(HO)_4$, $Sr^{iv}(HO)_4$, etc., the composition of which, however, is not fully decided.

I. It will be noticed in the formulas of the acids above given that the number of atoms of oxygen and of hydrogen are equal, and also that they are equal to the equivalence of the radical. Such acids, thus simply derived, I propose to call normal acids. A normal acid then, is one which contains as many atoms of oxygen and of hydrogen as is equal to the equivalence of the radical. They may be designated by prefixing *ortho* to the name of the acid, as proposed by Odling. Fixing now the acid termination *ic* for each group of the negative elements, the other terminations are readily obtained by the ordinary rule. Thus in the chlorine group, the radical in the *ic* acid has an equivalence of five; in the sulphur group, of six; in the nitrogen group, of five; and in the carbon group, of four. The acids in the above tables have consequently the following names :—

$Cl'(HO)$ Ortho-hypochlorous acid, $S''(HO)_2$ Ortho-hyposulphurous acid.
$Cl'''(HO)_3$ Ortho-chlorous acid, $S^{iv}(HO)_4$ Ortho-sulphurous acid.
$Cl^{v}(HO)_5$ Ortho-chloric acid, $S^{vi}(HO)_6$ Ortho-sulphuric acid.
$Cl^{vii}(HO)_7$ Ortho-perchloric acid,

$P'''(HO)_3$ Ortho-phosphorous acid, $Sn^{iv}(HO)_4$ Ortho-stannic acid.
$P^{v}(HO)_5$ Ortho-phosphoric acid.

In all the ortho acids the number of atoms of replaceable hydrogen, and therefore the basicity, is equal to the equivalence of the radical. Quite a number of these acids are known, either in the free state or in their salts. Of these, ortho-hypochlorous HClO, and hypo-bromous HBrO, ortho-iodous $H_3IO_3$, ortho-hyposulphurous $H_2SO_2$, ortho-nitrous $H_3NO_3$, ortho-boric $H_3BO_3$, ortho-carbonic $H_4CO_4$, silicic $H_4SiO_4$, stannic $H_4SnO_4$, and titanic $H_4TiO_4$, and ortho-antimonic acids $H_5SbO_5$ may be mentioned.

II. But it is at once evident that this simplicity of constitution of the acids is far from universal; indeed the large majority of acids have a composition essentially different. In general, the acids of the chlorine group are monobasic, those of the sulphur group dibasic, those of the nitrogen group mono- or tribasic, and those of the carbon group dibasic. The basicity of an acid containing a single atom of a perissad radical, however, is never even, nor that containing an artiad radical odd.

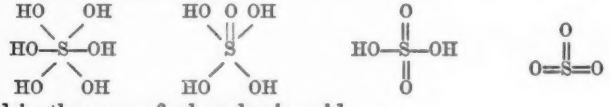
Now an acid, like any other ternary, may be formed by the union of two binaries; but in the case of acids, one of these binaries is water. Thus $Cl_2O$ hypochlorous oxyd uniting with hydric oxyd $H_2O$ gives $H_2Cl_2O_2$ or $(HClO)_2$, two molecules of ortho-hypochlorous acid. So $SO_3$ sulphuric oxyd, and $H_2O$ form $H_2SO_4$, the ordinary sulphuric acid. Conversely, abstraction of the elements of water from an acid yields again the negative oxyd or anhydrid. A false view of this fact it was, which gave rise to the old dualistic formulas, in which water is represented as existing as such in the acids. In all monobasic acids, however, two molecules of the acid are required to furnish one molecule of water; in dibasic acids, one molecule is required, in tribasic acids $\frac{2}{3}$ of a molecule, and in tetrabasic acids $\frac{1}{2}$ a molecule. The number of molecules of water which can be added to a negative oxyd to form an acid is determined by the equivalence of the simple radical which it contains. Thus in SO, sulphur is a dyad, and only a single molecule of water can be added to it, $SO+H_2O=H_2SO_2$, thus producing the normal acid. In $SO_2$, sulphur is a tetrad and two such additions are possible before reaching ortho-sulphurous acid, $SO_2+H_2O=H_2SO_3$, and $SO_2+(H_2O)_2=H_4SO_4$. In $SO_3$, sulphur is a hexad and three molecules of water may unite successively, $SO_3+H_2O=H_2SO_4$, $SO_3+(H_2O)_2=H_4SO_5$, and $SO_3+(H_2O)_3=H_6SO_6$, yielding finally the normal acid as before. The reverse process also is readily performed. Indeed, Graham long ago showed that a single molecule of tribasic phosphoric acid by the loss of $H_2O$, afforded a monobasic phosphoric acid. In the passage then, from the normal acids to the negative oxyds (or anhydrids), there may be as

many intermediate acids as successive abstractions of $H_2O$ from the normal acids, will permit. Thus, chlorine may yield

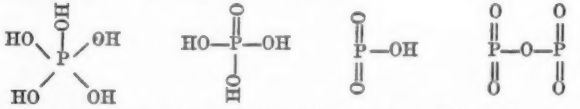
| | *Monad.* | *Triad.* | *Pentad.* | *Heptad.* |
|---|---|---|---|---|
| Ortho, | *HClO* | $H_3ClO_3$ | $H_5ClO_5$ | $H_7ClO_7$. |
| Mono-meta, | .... | *H ClO*$_2$ | $H_3ClO_4$ | $H_5ClO_6$. |
| Di-meta, | .... | .... | *H ClO*$_3$ | $H_3ClO_5$. |
| Tri-meta, | .... | .... | .... | *H ClO*$_4$. |

To the monobasic phosphoric acid which Graham obtained from the ordinary tribasic acid, by the removal of $H_2O$, he gave the name meta-phosphoric acid. And although the etymological signification of this prefix has entirely disappeared, yet it is so generally used in the science, that it may be well to retain it; and to define a meta-acid as one formed from an ortho-acid by the loss of one or more molecules of water. Moreover, since there may be several such acids, derived from a single ortho-acid, I propose to prefix the Greek numerals to the meta, in order to distinguish them; as in the above table, where ordinary chloric acid, being two removes from ortho-chloric acid, is named di-meta-chloric acid. Conversely by adding to the meta-acid the number of molecules of water indicated by the Greek numeral prefix, its corresponding ortho-acid is obtained.

From the foregoing considerations, the general conclusion may be drawn, that all acids are either ortho or meta-acids; the ortho-acids being formed by saturating all the free bonds of any negative radical by the monad hydryl; and the meta-acids being derived from these by the loss of the elements of water. It is plain then, that the equivalence of the radical is the same both in the normal acids and in those derived from them; and that they differ in the fact that in the former all the bonds are united to hydryl, while in the latter some of them are saturated by oxygen. This is very clearly represented by the graphic method. In the passage from ortho-sulphuric acid $H_6SO_6$ to the negative oxyd $SO_3$, we have



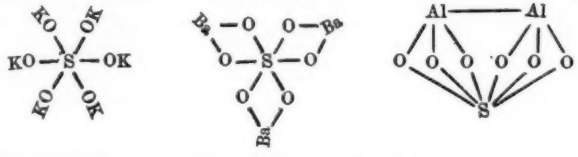
and in the case of phosphoric acid—



where finally, two molecules together losing $H_2O$, form phosphoric oxyd $P_2O_5$. It will be noticed that the tribasic acid, called by Odling ortho-phosphoric acid, is really mono-meta-phosphoric acid; while the common meta form is a di-meta-acid.

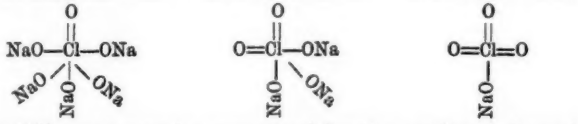
The above facts, we may remark in passing, throw much light on the manner of writing rational formulas. In all ternary compounds properly so called, the positive and the negative radicals are united by oxygen; indeed, this is the definition of an acid, a base and a salt. In all normal acids and their salts all the oxygen performs a linking function, thus:—

Potassic ortho-sulphate. Baric ortho-sulphate. Aluminic ortho-sulphate.



But in the derived or meta-acids a part of the oxygen is united with the radical by both its bonds, and hence takes no part in binding the radicals together.* In all the mono-meta acids one atom of oxygen is thus united, in the di-meta acids two, etc. For example,

Sodic mono-meta-perchlorate. Sodic di-meta-perchlorate. Sodic tri-meta-perchlorate.



This difference may be expressed by the ordinary formulas, thus: ortho salts Cl—OK, $S{=}(OK)_2$, $B{\equiv}(OK)_3$ etc.; meta, $(PO){\equiv}O_3Bi'''$, $(NO_2)$—OK, $(ClO_3)$—OAg, etc; or better in the form of the early typical formulas $\left.\begin{matrix}Cl'\\K\end{matrix}\right\}O$, $\left.\begin{matrix}S''\\Na_2\end{matrix}\right\}O_2$, $\left.\begin{matrix}B'''\\K_3\end{matrix}\right\}O_3$, and $\left.\begin{matrix}(PO)'''\\Bi'''\end{matrix}\right\}O_3$, $\left.\begin{matrix}(NO_2)'\\K\end{matrix}\right\}O$, $\left.\begin{matrix}(ClO_3)'\\Ag\end{matrix}\right\}O$. Hence it appears desirable that the form of the water type should be retained for rational formulas, since by it, this essential difference in the function of the oxygen may be readily indicated. $\left.\begin{matrix}(PO_2)'\\Cs\end{matrix}\right\}O$ designates at once cæsic di-meta-phosphate, $\left.\begin{matrix}(NO)'''\\Bi'''\end{matrix}\right\}O_3$ bismuthic mono-meta nitrate, $\left.\begin{matrix}(SO_2)''\\Mg''\end{matrix}\right\}O_2$ magnesic di-meta-sulphate, $\left.\begin{matrix}(SO)^{iv}\\Pt^{iv}\end{matrix}\right\}O_4$ platinic mono-meta-sulphate, $\left.\begin{matrix}(SO)''\\Na_2\end{matrix}\right\}O_2$

* This direct union is proved by the fact that this oxygen may be replaced by a radical of no uniting power, like the monad chlorine, for example, without breaking up the molecule; while the oxygen which unites the radicals to each other, cannot be so replaced without decomposing the molecule.

sodic mono-meta-sulphite, $\left.\begin{matrix}(ClO_3)'\\Rb\end{matrix}\right\}O$, rubidic tri-meta-perchlorate, etc.

With the knowledge of the constitution of the acids above given, it may be interesting to examine the various groups of acid-forming or negative radicals, to see how far they conform to the law. Commencing with the monads, the chlorine group is the only one which forms acids. All the possible ortho and meta acids of chlorine are given in the table, page 388. Of these, those in italics, all of which are monobasic, are known with certainty, though polybasic acids of chlorine have been supposed, on experimental grounds, to exist.* In the case of iodine, however, mono-meta-iodic acid $H_3IO_4$, or $\left.\begin{matrix}(IO)'''\\H_3\end{matrix}\right\}O_3$, and di-meta-iodic acid $HIO_3$ or $\left.\begin{matrix}(IO_2)'\\H\end{matrix}\right\}O$ are known; so also are mono-meta-periodic acid $H_5IO_6$, di-meta-periodic acid $H_3IO_5$, and tri-meta-periodic acid $HIO_4$. Ortho-hypoiodous acid $HIO$, is supposed to exist. The acids of bromine have been but little studied; ortho-hypobromous acid $HBrO$, and di-meta-bromic acid $HBrO_3$ are the only ones satisfactorily established.

The dyad negative radicals include the sulphur and the iron groups. The substances composing the latter group, however, form bases when they act as dyads, are ambiguous as tetrads, and only form acids when they are hexads. Selenium and tellurium form no compounds which are not yielded by sulphur. The latter may stand, therefore, as the representative of both groups. It may form

| | *Dyad.* | *Tetrad.* | *Hexad.* |
|---|---|---|---|
| Ortho-hyposulphurous | $H_2SO_2$. | sulphurous $H_4SO_4$. | sulphuric $H_6SO_6$ |
| Mono-meta | ..... | $H_2SO_3$ | $H_4SO_5$ |
| Di-meta | ..... | ..... | $H_2SO_4$ |

The three dibasic acids above given are the ordinary ones. But the two hydrates of sulphuric acid, so called, correspond to $H_6SO_6$ and $H_4SO_5$; and from these are obtained similar salts, as $Hg''_3SO_6$, and $Zn''_2SO_5$. The acids formed by the iron group are similar to those of hexad sulphur, the di-meta form being the more common; as in $H_2CrO_4$, $H_2MnO_4$, and $H_2FeO_4$. Chromium, however, forms acids, whose salts are well known, corresponding to the three sulphuric acids above given. With mercury and bismuth, there are the ortho-chromates $Hg''_3CrO_6$ and $Bi'''_2CrO_6$; and with lead, the mono-meta-chromate $Pb''_2CrO_5$. Manganese in its tetrad stage, appears capable of forming a mono-meta acid, corresponding to

* Crystallized hydric perchlorate, according to Roscoe, is $H_3ClO_5$ the di-meta form.

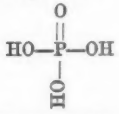
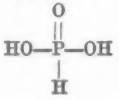
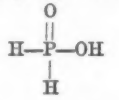
$H_2SO^3$. No true permanganic acid is known; since the acid so-called does not contain the metal as an octad. If its formula be written $HMnO_4$, monobasic, as the isomorphism of its salts with the perchlorates would seem to require, then manganese must be a heptad like chlorine; nor do we escape from this conclusion by writing it $H_2Mn_2O_8$, as will be seen farther on.

The acids of triad radicals may be divided into two groups; those of boron and gold, which have no higher equivalence: and those of nitrogen, phosphorus, arsenic, antimony, and bismuth, which have a quinquivalent stage. Of the former, boron forms an ortho-acid $H_3BO_3$ and a mono-meta-acid $HBO_2$; gold only a mono-meta-auric acid, $HAuO_2$. The acids of the nitrogen group may be represented as follows:

| | *Triad.* | | *Pentad.* |
|---|---|---|---|
| Ortho-nitrous | $H_3NO_3$ | nitric | $H_5NO_5$ |
| Mono-meta | $H\,NO_2$ | | $H_3NO_4$ |
| Di-meta | ..... | | $H\,NO_3$ |

Salts have been obtained corresponding to all these acids of nitrogen; as plumbic ortho-nitrite $Pb''_3(NO_3)_2$, and potassic mono-meta nitrite $KNO_2$; dihydro-bismuthic ortho-nitrate $H_2Bi'''NO_5$, magnesic mono-meta-nitrate $Mg''_3(NO_4)_2$ and sodic di-meta-nitrate $NaNO_3$. No acid of triad phosphorus is known, if we except the calcic ortho-phosphite $Ca''_3(PO_3)_2$, corresponding to it. As quinquivalent however, all the above acids of phosphorus are known; the mineral libethenite is hydro-di-cupric ortho-phosphate $HCu''_2PO_5$; and triple phosphate dried at 100° C., has the formula $H_2(NH_4)MgPO_5$, di-hydro-ammonio-magnesic ortho-phosphate. Similar salts of iron and manganese have been obtained. The mono-meta-phosphoric acid $H_3PO_4$ is the ordinary tribasic form (Odling's ortho-acid), and the di-meta acid is the common monobasic or meta acid of Graham. It may here be remarked that the acids, called hypophosphorous and phosphorous, are misnamed, since the radical phosphorus is not trivalent in the latter and univalent in the former as analogy with the other acids, and indeed as the principles of nomenclature would require; but as Frankland has represented, both these acids contain phosphorus as a pentad. If the principles above stated be correct, it is evident that the number of atoms of basic hydrogen can never exceed those of the oxygen by which it is linked to the acid radical. In $H_3PO_2$ the hydrogen is in excess, and it is at once apparent that the acid cannot be tribasic; that one atom of the hydrogen at least, must be united directly with the phosphorus. Experiment shows us that in fact two atoms of hydrogen are thus directly united, the acid being monobasic. Its rational formula, therefore, is

$(H_2PO)'_H\}O$, and it may be viewed as di-meta-phosphoric acid $(PO_2)'_H\}O$, in the radical of which $H_2$ has replaced O. In phosphorous acid $H_3PO_3$, a single atom of hydrogen being united directly to the phosphorus, the other two are replaceable by basic metals, yielding acid and neutral salts, having the formulas $^{(HPO)''}_{HR}\}O_2$ and $^{(HPO)''}_{R_2}\}O_2$ as Rammelsberg has shown. All three hydrogen atoms may be replaced by the alcoholic radicals, forming neutral ethers; but only two atoms of this radical—those which have replaced the basic hydrogen—can be exchanged for a metal, to form salts. The third atom, replacing as it does, the alcoholic hydrogen, is still retained, forming alcoholic phosphorous acids. The constitution of these acids may be graphically represented thus:

| Phosphoric acid. | Phosphorous acid. | Hypophosphorous acid. |
|---|---|---|
|  |  |  |

Since they are formed from mono-meta-phosphoric acid by replacing hydryl by hydrogen, they resemble the phosphoric chlorhydrines, to be considered farther on.

Acid compounds of arsenic exist, corresponding to all the forms given above. Plumbic ortho-arsenite $Pb''_3(AsO_3)_2$, hydro-cupric ortho-arsenite $HCu''AsO_3$, and di-hydro-potassic ortho-arsenite $H_2KAsO_3$; plumbic and potassic mono-meta-arsenites, $Pb''(AsO_2)_2$ and $KAsO_2$; hydro-di-cupric ortho-arsenate $HCu''_2AsO_5$ (olivenite), sodic mono-meta-arsenate $Na_3AsO_4$, and potassic di-meta-arsenate $KAsO_3$, are examples. Antimony forms argentic ortho-sulphantimonite $Ag_3SbS_3$ (pyrargyrite), argentic mono-meta-sulphantimonite $AgSbS_2$ (miargyrite) and mono-meta-antimonous acid $HSbO_2$; ortho-antimonic acid $H_5SbO_5$, mono-meta antimonic acid $H_3SbO_4$, (and the salts $Pb''_3(SbO_4)_2$ and $K_3SbS_4$) di-meta-antimonic acid $HSbO_3$ and potassic di-meta-antimonate $KSbO_3$. The compounds of bismuth are little known. Kobellite is a plumbic ortho-sulph-bismuthite $Pb''_3(BiS_3)_2$; and di-meta-bismuthic acid $HBiO_3$ has also been obtained.

The negative radicals of the tetrad group include carbon, silicon, tin and titanium. Carbon may form

| | |
|---|---|
| Ortho-carbonous acid $H_2CO_2$ | carbonic $H_4CO_4$ |
| Mono-meta ..... | $H_2CO_3$ |

Of the first, there is evidence to believe it is represented by formic acid.* Both ortho-and meta-carbonic acids form numerous salts. Calcic ortho-carbonate $Ca''_2CO_4$, cupric ortho-carbonate $Cu''_2CO_4+aq$ (malachite) and hydro-tri-cupric ortho-carbonate $H_2Cu''_3(CO_4)_2$, (azurite) are examples of the former; and the common carbonates $K_2CO_3$, $BaCO_3$, etc., of the latter. The division of the silicates into ortho-and meta-salts, has been very clearly represented by Prof. Dana in the last number of this Journal. Ortho- and meta-stannates and titanates are well known compounds.

Of radicals having a higher equivalence, the pentads tantalum and columbium, forming a series of acids similar to quinquivalent phosphorus, and the hexads molybdenum, vanadium and tungsten, whose acids correspond to those of sexivalent sulphur, may here be mentioned.

The compounds thus far considered are derived from negative radicals; but, as already intimated, positive elements form a similar series of bodies. Since the equivalence of positive radicals rarely varies, but a single ortho-base of the same radical is known. Of ortho-bases, ortho-potassic base HKO, ortho-calcic base $H_2CaO_2$, and ortho-zirconic base $H_4ZrO_4$, are examples. The mineral pyrochroite is ortho-manganous base, $H_2MnO_2$ and brucite is ortho-magnesic base $H_2MgO_2$. From these, by the loss of the elements of water come the meta-bases, as meta-zirconic base $H_2ZrO_3$ but they are few in number. The perhydrates of the alkaline earths, so called, are probably meta-bases; as mono-meta-baric base $H_2BaO_3$ or $\left.\begin{matrix}(BaO)''\\H_2\end{matrix}\right\}O_2$, mono-meta-calcic base $H_2CaO_3$ or $\left.\begin{matrix}(CaO)''\\H_2\end{matrix}\right\}O_2$.

III. There is a third class of acids which is not included in either of the divisions above given. I refer to those which contain more than a single atom of the radical. Since they are derived from the ortho-acids, they are evidently meta-acids. The most familiar example is pyrophosphoric acid, $H_4P_2O_7$, derived from two molecules of ortho-phosphoric acid $H_3PO_5$ by the loss of the elements of three molecules of water, $H_{10}P_2O_{10}-(H_2O)_3=H_4P_2O_7$. A simple method of naming these acids is suggested by the principles already given. All acids derived from two molecules of phosphoric acid, for example, may be called di-phosphoric acids;† and the number of

* This Journal, II, xliv, 263, Sept. 1867.

† As has already been proposed by Wurtz (Chemical Philosophy, London, 1867, 159), Schiff (Ann. Ch. Pharm., IV. Suppl., 30), Naquet (Chimie, 2d ed. i, 172), Frankland (Lecture notes, 103), Rammelsberg (Chemie, Berlin, 1867, 292), (Weltzien, Syst. Uebers. der Silicate, Giessen, 1864,) and others, though in a modified

molecules of water lost, to yield the meta-acid may be indicated by a numeral prefix to the meta, as above. Hence, as pyrophosphoric acid becomes tri-meta-di-phosphoric acid. A rule for naming may be given, as follows; Prefix to the name of the acid, the numeral corresponding to the number of atoms of the negative radical contained in the formula. Then add the elements of water until the oxygen and the hydrogen atoms are equal; the numeral indicating the number of molecules of water thus employed, is to be prefixed to the word meta, placed before the name of the acid. For example, Fleitmann and Henneberg obtained two soda salts, referable to the acids $H_6P_4O_{13}$ and $H_{12}P_{10}O_{31}$. The first is a tetra-phosphoric acid, the ortho-acid of which is reproduced by adding to it seven molecules of water. The second is derived from deca-phosphoric acid, by the loss of nineteen molecules of water. Hence the salts are sodic hepta-meta-tetra-phosphate and sodic enneadeca-meta-deca-phosphate; meaning that the former is derived from four molecules of the ortho-acid by the loss of seven molecules of water, and the latter is nineteen removes from ten acid molecules. These acids and their derivatives are exceedingly numerous. Wurtz is inclined to view them as accumulated bodies, similar to the polyethylenic alcohols; stating that as PbO may be added to $\left.\begin{matrix}Pb''\\H_2\end{matrix}\right\}O_2$, producing $\left.\begin{matrix}Pb''\\Pb''\\H_2\end{matrix}\right\}O_3$ and $\left.\begin{matrix}Pb''\\Pb''\\Pb''\\H_2\end{matrix}\right\}O^4$, so to $\left.\begin{matrix}(SO_2)''\\H_2\end{matrix}\right\}O_2$, $(SO_2)''O$ may be added, yielding the fuming or Nordhausen sulphuric acid $\left.\begin{matrix}(SO_2)''\\(SO_2)''\\H_2\end{matrix}\right\}O_3$ equal to $H_2S_2O_7$, our penta-meta-di-sulphuric acid. This process, however, leaves the basicity of the acid unaltered; and hence is insufficient in many cases.

The number of these acids may be illustrated by a table, showing the di- and tri-acids of the tetrad silicon, and of the pentad phosphorus, with the various meta acids derived from them, as follows:

sense. In the places above cited these authors speak of di-silicic acid, referring apparently, to any acid containing two silicon atoms. The normal di-silicic acid of these writers, however, is $H_6Si_2O_7$; whereas my di-silicic acid is $H_8Si_2O_8$, two molecules of ortho-silicic acid, from which by the loss of $H_2O$, is obtained $H_2Si_2O_7$, mono-meta-di-silicic acid.

| | *Di-acid.* | | *Tri-acid.* | |
|---|---|---|---|---|
| | *Tetrad.* | *Pentad.* | *Tetrad.* | *Pentad.* |
| Ortho, | $H_8Si_2O_8$* | $H_{10}P_2O_{10}$* | $H_{12}Si_3O_{12}$* | $H_{15}P_3O_{15}$* |
| Mono-meta, | $H_6Si_2O_7$ | $H_8P_2O_9$ | $H_{10}Si_3O_{11}$ | $H_{13}P_3O_{14}$ |
| Di-meta, | $H_4Si_2O_6$* | $H_6P_2O_8$* | $H_8Si_3O_{10}$ | $H_{11}P_3O_{13}$ |
| Tri-meta, | $H_2Si_2O_5$ | $H_4P_2O_7$ | $H_6Si_3O_9$* | $H_9P_3O_{12}$* |
| Tetra-meta, | $Si_2O_4$ | $H_2P_2O_6$* | $H_4Si_3O_8$ | $H_7P_3O_{11}$ |
| Penta-meta, | | $P_2O_5$ | $H_2Si_3O_7$ | $H_5P_3O_{10}$ |
| Hexa-meta, | | | $Si_3O_6$ | $H_3P_3O_9$* |
| Hepta-meta, | | | | $H\ P_3O_8$ |

A few examples of well known compounds, formed in this way, will make the preceding remarks clear.

| | |
|---|---|
| Cupric mono-meta-di-arsenite, | $Cu_2As_2O_5$ (Scheele's green) |
| Plumbic tri-meta-di-arsenate, | $Pb_2As_2O_7$ |
| Ferric tri-meta-di-sulphate, | $Fe^{vi}S_2O_9$ |
| Potassic penta-meta-di-chromate, | $K_2Cr_2O_7$ |
| Penta-meta-di-periodic acid, | $H_4I_2O_9$ |
| Di-hydro-plumbic mono-meta-tri-carbonate, | $H_2Pb_4C_3O_{11}$ (white lead). |
| Hepta-meta-tri-iodic acid, | $HI_3O_8$ |
| Plumbic tri-meta-tetra-sulphantimonite, | $Pb_3Sb_4S_9$ (Jamesonite). |
| Sodic penta-meta-tetra-borate, | $Na_2B_4O_7$ (borax). |
| Potassic ennea-meta-tetra-iodate, | $K_2I_4O_{11}$ |
| Ennea-meta-tetra-periodic acid, | $H_{10}I_4O_{19}$ |
| Plumbic penta-meta-hexa-sulphantimonite, | $Pb_4Sb_6S_{13}$ (plagionite). |
| Magnesic ennea-meta-octo-borate, | $Mg_3B_8O_{15}$ (boracite). |

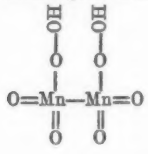
IV. In the formulas of these and similar substances the atoms of the negative radical are united to each other by oxygen, as Frankland has already shown for many of them.† It is evident, however, that these atoms may unite directly together, in which case two units of attraction in each pair of atoms will be occupied in uniting them. The equivalence of the group will then be represented by the law of saturation $E=S-2(n-1)$, already given. Certain artiads have a particular tendency to combine in this manner; as mercury in $Hg_2Cl_2$ and copper in $Cu_2H_2$; and particularly the iron group of metals, which were long supposed to be triads for this reason. Two atoms of a

* The compounds thus indicated are not distinct acids, but are multiples of the simple ortho or meta forms. See Wurtz' Chemical Philosophy, London, 1867, 158, note. It may here be remarked that monobasic phosphoric acid is capable of forming a series of polymeric compounds corresponding to the multiples given above. With silver, for example, $Ag_2P_2O_6$, $Ag_3P_3O_9$ and $Ag_6P_6O_{18}$ have been obtained. They are called di-, tri- and hexa-meta-phosphates, respectively. In the table, the first appears as tetra-meta-di-phosphate, and the second as hexa-meta-tri-phosphate.

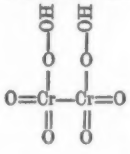
† Lecture notes for chemical students, London, 1866.

tetrad directly united, lose two bonds, and together act as a hexad. $Fe_2Cl_6$ or $Fe^{vi}Cl_6$ $Mn^{vi}O_3$, $Co^{vi}S_3$, $Cr^{vi}Cl_6$, etc., are examples of binaries so formed. With hydryl the compounds produced are quite numerous, and many of them occur as minerals. Thus ortho-ferric base $H_6Fe^{vi}O_6$ is limonite, and ortho-aluminic base $H_6Al^{vi}O_6$ is gibbsite. From these are derived the meta-bases; as from $H_6Al^{vi}O_6$ comes $H_4Al^{vi}O_5$ mono-meta-aluminic base, and $H_2Al^{vi}O_4$ di-meta-aluminic base, diaspore. So from limonite $H_6Fe^{vi}O_6$ may be obtained $H_4Fe^{vi}O_5$ mono-meta-ferric base (xanthosiderite) and $H_2Fe^{vi}O_4$ di-meta-ferric base (Göthite). Manganite $H_2Mn^{vi}O_4$ is di-meta-manganic base. Permanganic and perchromic acids, $H_2Mn_2O_8$ and $H_2Cr_2O_8$, as was stated on page 389, must contain their radicals as heptads, if their atoms are united by oxygen. Frankland, however, to avoid a violation of the fundamental law of saturation, supposes that the manganese and chromium atoms are directly united, and makes an oxygen atom intervene between each negative atom and the hydryl, thus :—

Permanganic acid.



Perchromic acid.



On either supposition, their constitution is anomalous.

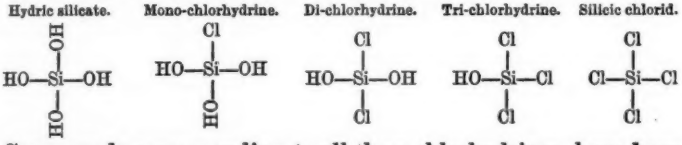
The same direct union takes place with the carbon group of tetrads forming $C^{vi}Cl_6$, $Sn^{vi}O_3$, $Ti^{vi}N_2$, etc. With hydryl, therefore, such a series of compounds as the following, becomes possible.

| | *Carbon.* | *Silicon.* |
|---|---|---|
| Ortho-oxalic acid, | $H_6C^{vi}O_6$ | $H_6Si^{vi}O_6$ |
| Mono-meta-oxalic acid, | $H_4C^{vi}O_5$ | $H_4Si^{vi}O_5$ |
| Di-meta-oxalic acid, | $H_2C^{vi}O_4$ | $H_2Si^{vi}O_4$ |
| Di-carbonic tri-oxyd, | $C^{vi}O_3$ | $Si^{vi}O_3$ |

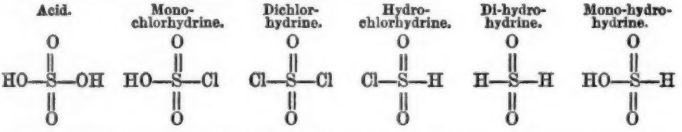
In the carbon series, the di-meta form is ordinary oxalic acid, from which the group may be named. The ortho-oxalic acid is represented in plumbic ortho-oxalate $Pb''_3C^{vi}O_6$ but the mono-meta acid seems to be unknown. The silicon compounds do not appear to be known with certainty, although several observers have reported the discovery of a di-silicic tri-oxyd (sesquioxyd of silicon) with some of the hydrates belonging to it.

The view which has now been given, of the constitution of acids and bases, renders very simple the relation of these bodies to the chlorhydrines, so-called. An acid being converted into

a chlorhydrine by exchanging its hydryl (HO)′ for the monad chlorine (from which fact the word chlorhydrine comes) it is evident that there may be as many chlorhydrines obtained from a given ortho or meta acid, as is equal to the number of atoms of its basic hydrogen, less one, the final product being the chlorid of the radical. Thus with ortho-silicic acid, there may be




Compounds corresponding to all these chlorhydrines, have been obtained by Friedel and Crafts.* If the acid be a meta-acid, the radical is partially saturated by oxygen, and the final result is a so-called oxychlorid (the chlor-aldehyd of Odling); the true aldehyd being a similar body, containing hydrogen in place of chlorine. For example, di-meta-sulphuric acid may form in this way the following bodies:




A comparison of these formulas with those of hypophosphorous and phosphorous acids on page 392, will make clear the relation of these acids to mono-meta-phosphoric acid, by showing that they are its hydro-hydrines, the last of the series, $H_3PO$ phosphoric aldehyd, not being yet known.

The results given in the foregoing pages may be briefly recapitulated. I have attempted to show:

1. That all the bonds of any simple radical may be saturated by the monad hydryl.

2. That the compounds thus formed, are determined by the electro-chemical character of the radical; being acids when it is negative, and bases when it is positive.

3. That acids and bases so formed, being evidently normal, are conveniently designated by the prefix *ortho.*

4. That the equivalence of negative radicals varies through several stages, while that of positive rarely changes. And hence, that there may be a series of ortho acids from a given negative radical, but only a single base from a positive one.

5. That by the removal of the elements of water from a normal or ortho acid, a derived acid is produced, which may be indicated by the prefix *meta.*

* This Journal, II, xliii, 155, March, 1867.

6. That when there are several such derivatives, the Greek numeral prefixes di, tri, tetra, etc., may be used to indicate the number of molecules of water removed from the ortho acid to yield the meta-form.

7. That intermediate between the simple ortho- and meta-acids, are others containing more than a single atom of the negative radical; and that these acids may be designated by di, tri, tetra, etc., (according to the number of negative atoms) prefixed to the name of the acid, while the number of molecules of water removed from a multiple of the normal acid to form them is indicated by the same numerals prefixed to the meta.

8. That while the negative atoms in the compounds just mentioned are united by oxygen, there may be other compounds whose negative or positive atoms are united directly; thus producing a fourth class of acids and of bases.

By classifying thus the substances known as acids and bases, —and of course the salts derived from them—it is hoped that their relations to each other may be made clearer. And by giving them systematic names, their position in the series may be fixed, and a step be taken toward the establishment of a rational nomenclature.

New Haven, Oct. 10, 1867.

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ART. XLIII.—*Crystallogenic and Crystallographic Contributions; by* JAMES D. DANA. *On the Feldspar group of Minerals; supplementary to* ART. XXIX, *page* 252: *On the Chemical Formulas of the Silicates.*

1. *Chemical formulas of the Feldspars, and of some other Silicates.*

THE resemblance or affiliation between the species of the Feldspar group is of the most intimate kind. There is not merely isomorphism (or close approximation in crystalline form), which, when alone, is of little value in determining relations, but also, apparently, the profoundest *isotypism*. For the approximation includes near identity in (*a*) the habitual forms; (*b*) the direction and facility of the two cleavages; (*c*) the hardness; (*d*) the color, and tendency to opalescence; (*e*) all optical characteristics; and as regards chemical composition, they agree in consisting of silica, alumina, and an alkali or alkaline earth, to the exclusion of magnesium and iron; and the oxygen ratio between the protoxyds and sesquioxyds* is for

* The expression "oxygen ratio between the protoxyds and sesquioxyds," is equivalent, under the new system, to the ratio between the combining powers of the protoxyd or dyad and sesquioxyd or pseudotriad metals," the so-called dyad

each 1 : 3. The group, therefore, is one in nature, and chemistry must have some explanation of this unity. The following observations bear on the question of its origin.

1. The oxygen ratios for the protoxyds, sesquioxyds, and silica, in the different Feldspars, are as follows:

| | Ṙ Ẍl Si | | Ṙ Ẍl Si |
|---|---|---|---|
| Anorthite | 1 : 3 : 4 | Oligoclase | 1 : 3 : 9 |
| Labradorite | 1 : 3 : 6 | Albite | 1 : 3 : 12 |
| Andesine, Hyalophane | 1 : 3 : 8 | Orthoclase | 1 : 3 : 12 |

[The ratio 1 : 3 for the *basic oxyds* is expressed in the formula $\dot{R}+\ddot{Al}$, or $(\frac{1}{4}\dot{R}^3+\frac{3}{4}\ddot{Al})$; and, for the *basic metals*, in the formula $R+3\beta Al$, or $(\frac{1}{4}R+\frac{3}{4}\beta Al)$; or if the perissads are distinctly indicated, in the formula $(R, R_2)+3\beta Al$, or $(\frac{1}{4}(R, R_2)+\frac{3}{4}\beta Al)$.]

Besides the above-mentioned ratios, some analyses afford 1 : 3 : $4\frac{1}{2}$, 1 : 3 : 5, 1 : 3 : $5\frac{1}{2}$, and other ratios between 1 : 3 : 4 and 1 : 3 : 6; and so also intermediate ratios between 1 : 3 : 6 and 1 : 3 : 8; between 1 : 3 : 8 and 1 : 3 : 9; and between 1 : 3 : 9 and 1 : 3 : 12. But these cases, (and also those in which there is some variation from the ratio 1 : 3,) are usually regarded as exceptional to the above as the true normal ratios; and they have been attributed to the following causes:

(*a*) Incorrect analyses.

(*b*) Impurities: and often mixtures of different feldspars through inter-crystallization, some remarkable examples of which have been detected by microscopic and optical examinations.

(*c*) Alteration; caused either (1) by the infiltration of ordinary waters carbonated or not —such waters filtered through powdered feldspar being known to become alkaline in a short time, and the rocks containing feldspars having been exposed to this action through long ages past; and examples being numerous of the alteration of feldspars, ending in their kaolinization, in which both alkalies and silica are lost; or (2) through the same process aided by mineral ingredients in the waters, resulting in the introduction of magnesia, oxyds of iron, etc., and in other changes.

As regards the views here presented, it matters not whether these intermediate ratios are irregularities produced by the above methods, or are normal ratios.

group here including not only Ca, Mg, Fe, etc., but also $K_2$, $Na_2$, $Li_2$, etc., as illustrated in the classification on p. 204 of the former paper. I use beyond the expressions of the old system, as they are intelligible to all chemical readers, whether versed in the new system or not.

2. The oxygen ratio in Anorthite is that of a Unisilicate, for $1 + 3 : 4 = 1 : 1$; and the formula may be, on the old and new system:

Old $(\frac{1}{4}\dot{R}^3+\frac{3}{4}\ddot{A}l)^2\breve{S}i^3$ New $Si|O_4|(\frac{1}{4}R,+\frac{3}{4}\beta Al)^2$

In the other species, the oxygen ratios vary from that of Anorthite, through an increase in the proportion of silica, they being as follows:

| | Bases | | Silica | | Bases | | Silica |
|---|---|---|---|---|---|---|---|
| Labradorite | 1 | : | $1\frac{1}{2}$ | Oligoclase | 1 | : | $2\frac{1}{4}$ |
| Andesine, Hyalophane | 1 | : | 2 | Albite | 1 | : | 3 |
| | | | | Orthoclase | 1 | : | 3 |

3. The silica of a Unisilicate is enough for the making of a feldspar; that is, to produce a species having that assemblage of crystalline, physical and other qualities which characterize the group. The type is therefore essentially *Unisilicate.* But while Unisilicate, it admits of increase in the proportion of silica to produce its variety of species.

4. An excess of silica above that of a Unisilicate may exist under the Unisilicate type in one of the two following conditions, and still be not an impurity.

A. It may be *basic* silica; in which case the general formula for the group would be—

Old $(\dot{R}^3,\ddot{A}l,\breve{S}i^{\frac{3}{2}})^2\breve{S}i^3$ New $Si|O_4|(R, R_2), \beta Al, \gamma Si)_2$

and the special formulas for the species are:

| | | |
|---|---|---|
| Labradorite | $(\frac{1}{5}\dot{R}^3+\frac{2}{5}\ddot{A}l+\frac{1}{5}\breve{S}i^{\frac{3}{2}})^2\breve{S}i^3$ | $Si\|O_4\|(\frac{1}{5}(R, R_2)+\frac{2}{5}\beta Al+\frac{1}{5}\gamma Si)_2$ |
| Andesine | $(\frac{1}{8}\dot{R}^3+\frac{3}{8}\ddot{A}l+\frac{2}{8}\breve{S}i^{\frac{3}{2}})^2\breve{S}i^3$ | $Si\|O_4\|(\frac{1}{8}(R, R_2)+\frac{3}{8}\beta Al+\frac{2}{8}\gamma Si)_2$ |
| Oligoclase | $(\frac{2}{13}\dot{R}^3+\frac{6}{13}\ddot{A}l+\frac{5}{13}\breve{S}i^{\frac{3}{2}})^2\breve{S}i^3$ | $Si\|O_4\|(\frac{2}{13}(R, R_2)+\frac{6}{13}\beta Al+\frac{5}{13}\gamma Si)_2$ |
| Albite | $(\frac{1}{8}\dot{N}a^3+\frac{3}{8}\ddot{A}l+\frac{4}{8}\breve{S}i^{\frac{3}{2}})^2\breve{S}i^3$ | $Si\|O_4\|(\frac{1}{8}Na_2+\frac{3}{8}\beta Al+\frac{4}{8}\gamma Si)_2$ |
| Orthoclase | $(\frac{1}{8}\dot{K}^3+\frac{3}{8}\ddot{A}l+\frac{4}{8}\breve{S}i^{\frac{3}{2}})^2\breve{S}i^3$ | $Si\|O_4\|(\frac{1}{8}K_2+\frac{3}{8}\beta Al+\frac{4}{8}\gamma Si)_2$ |

R (or $R, R_2$) in Labradorite, Andesine and Oligoclase = Ca, Na, with occasionally some K; in Hyalophane, which has the formula of Andesine, = Ba and Na; Ba replacing the Ca of other feldspars. These formulas are partially presented on page 260.

B. It may be *accessory* silica; by which is meant, not an ingredient unessential to the species, but a true component, accessory to the fundamental type of the series.* The formulas on this view would be:—

* This idea of the feldspars is recognized by the author in the last edition of his Mineralogy (1854) in which he heads the group as follows: "Type ratio for the oxygen of bases and silica 1 : 1, and varying from this by the addition of silica to the type"; and gives the following as the formulas:

| | | | |
|---|---|---|---|
| Anorthite | $(\dot{R} + \ddot{A}l)\breve{S}i^{\frac{4}{3}}$ | Oligoclase | $(\dot{R} + \ddot{A}l)\breve{S}i^3$ |
| Andesine | $(\dot{R} + \ddot{A}l)\breve{S}i^{\frac{5}{3}}$ | Albite | $(\dot{R} + \ddot{A}l)\breve{S}i^4$ |
| Labradorite | $(\dot{R} + \ddot{A}l)\breve{S}i^2$ | Orthoclase | $(\dot{R} + \ddot{A}l)\breve{S}i^4$ |

| | | |
|---|---|---|
| Anorthite | $(\frac{1}{2}\dot{R}^3+\frac{1}{2}\ddot{A}l)^2\breve{S}i^2$ | $Si\|O_4\|(\frac{1}{2}R+\frac{1}{2}\beta Al)_2$ |
| Labradorite | $(\frac{1}{2}\dot{R}^3+\frac{1}{2}\ddot{A}l)^2\breve{S}i^6+\frac{3}{2}\breve{S}i$ | $Si\|O_4\|(\frac{1}{2}(R,\ R_2)+\frac{1}{2}\beta Al)_2+\frac{1}{2}SiO^2$ |
| Andesine, Hyalophane | $(\frac{1}{2}\dot{R}^3+\frac{1}{2}\ddot{A}l)^2\breve{S}i^6+3\breve{S}i$ | $Si\|O_4\|(\frac{1}{2}(R,\ R_2)+\frac{1}{2}\beta Al)_2+SiO^2$ |
| Oligoclase | $(\frac{1}{2}\dot{R}^3+\frac{3}{4}\ddot{A}l)^2\breve{S}i^3+3\frac{1}{2}\breve{S}i$ | $Si\|O_4\|(\frac{1}{2}(R,R_2)+\frac{1}{2}\beta Al)_2+1\frac{1}{2}SiO^2$ |
| Orthoclase, Albite | $(\frac{1}{2}\dot{R}^6+\frac{1}{2}\ddot{A}l)^2\breve{S}^6+6\breve{S}i$ | $Si\|O_4\|(\frac{1}{2}R_2+\frac{1}{2}\beta Al)_2+2SiO^2$ |

According to either of these two methods, A or B, any other proportions of silica exceeding that of the Unisilicate may be expressed in the same manner as the above.

The last of the formulas under A, if expanded, becomes,—

| | |
|---|---|
| Old | $(\dot{R}^3)^2\ \breve{S}i^6\ +\ 3\ddot{A}l^2\breve{S}i^6\ +\ 4\overset{3}{\breve{S}i}^2\breve{S}i^6$ |
| New | $Si\|O_4\|(R_2)_2\ +\ 3[Si\|O_4\|\beta Al_2]\ +\ 4[Si\|O_4\|_7Si_2]$ |

in which the last member consists of silica alone; and thus the formula approaches the corresponding one under B, yet with this important difference, that the silica in this member is in the former in two states, a basic and an acid.

5. *The excess of silica above the amount required for the Unisilicate increases with the increase of the alkalies, or the perissad elements, in the base.*

In Anorthite, true unisilicate feldspar, the base consists of lime without alkalies. But in the other feldspars, with higher silica, it is partly soda or potash, with lime, or in one case (Hyalophane) baryta; or it is wholly soda or potash. The ratios of non-alkaline to alkaline constituents in the bases in these species are, for the average results of analyses, as follows:

| | Non-alk. : Alk. | | Non-alk. : Alk. |
|---|---|---|---|
| Labradorite | 2 : 1 | Oligoclase | 1 : 2 |
| Hyalophane | $1\frac{1}{3}$ : 1 | Orthoclase | all alkali. |
| Andesine | 1 : 1 | Albite | all alkali. |

Thus the above statement is fully sustained by the average results of the analyses. Looking to special analyses, it will be found that in general those Labradorites which contain less than the normal proportion of silica (and so approach Anorthite) are those which contain *most* lime in proportion to the alkali; and those which give the oxygen ratio 1 : 3 : 6·5, 1 : 3 : 7 are those which contain *least* lime relatively to the amount of alkali; and so for the ratios between 1 : 3 : 8 and 1 : 3 : 9, and others between 1 : 3 : 9 and 1 : 3 : 12. There are exceptions to this statement, as should be expected when we consider the diversity of causes (see p. 309) which may have aided in producing these intermediate ratios. But the cases in accordance are sufficient to sustain it.

It would seem, therefore, that this excess of silica is dependent in part, if not wholly, on the alkaline or perissad nature of the base.

There is a prominent exception to this view in the species Leucite, which, although *isometric* in crystallization, is regarded as of the Feldspar group, since it has a similar general constitution, with the Andesine ratio 1 : 3 : 8. For although it is thus related to Andesine, the protoxyd base is solely alkaline. Yet, as it stands apart in its isometric crystallization, it may not be as certainly in opposition as would at first seem. It may belong with Sodalite and Haüynite to an independent series in the group. Sodalite (with Haüynite) has the anorthite ratio 1 : 3 : 4, and is a soda species; while Leucite, with 1 : 3 : 8, is a related potash species; and if the two are in an independent series, it would appear that potash is more strongly determinative of the higher ratio of silica than soda.

6. Facts exist among other silicates that throw some light on this subject.

A. The Mica group has the following for the oxygen ratios between the bases and silica:

| | Bases | Silica | | Bases | Silica |
|---|---|---|---|---|---|
| 1. Astrophyllite | 1 | 1 | 5. Muscovite | 1 | $1\frac{1}{4}$ |
| 2. Phlogopite | 1 | 1 | 6. Lepidolite | 1 | $1\frac{1}{2}$ |
| 3. Biotite | 1 | 1 | 7. Cryophyllite | 1 | 2 |
| 4. Lepidomelane | 1 | 1 | | | |

Now the ratios of the non-alkaline to alkaline constituents of the protoxyd bases in these species, as deduced from the average results of analyses, are as follows:

| | Non-alk. : Alk. | | Non-alk. : Alk. |
|---|---|---|---|
| 1. Astrophyllite | 6 : 1 | 5. Muscovite | 1 : 2 to 6 |
| 2. Phlogopite | 6 : 1 | 6. Lepidolite | 1 : 3 to 12 |
| 3. Biotite | 3 : 1 | 7. Cryophyllite | almost solely alk. |
| 4. Lepidomelane | 2–1 : 1 | | |

The non-alkaline part of the protoxyd base in the species is mostly magnesia and protoxyd of iron, with some lime; and the alkaline, mostly potash, except in Lepidolite and Cryophyllite, which contain also lithia. The protoxyd bases are most exclusively alkaline in Cryophyllite.

The parallelism with the Feldspar group is striking; and there may be the same reason, therefore, for the increase of the silica, and not that mentioned on page 259.

B. Again, among Unisilicates, the Meionite section of the Scapolite group illustrates the same principle. The species Meionite, Mizzonite and Marialite are closely alike in crystallographic and physical qualities, so much so that Mizzonite has generally been made a variety of Meionite; and Marialite if it had been as long described would probably have shared the same fate. (It was first announced by vom Rath last year in the Zeitschr. d. deutschen geol. Ges., xviii, 635).

The oxygen ratios, and the ratios of the non-alkaline to the alkaline portion of the protoxyd bases, are as follows:

| | Ṙ : Ṙ : Si | Ṙ+Ṙ : Si | Non-alk. : Alk. |
|---|---|---|---|
| Meionite | 1 : 1 : 2 | 1 : 1 | 10 : 1 |
| Mizzonite | 1 : 2 : 5¼ | 1 : 1¾ | 1 : 1¾ |
| Marialite | 1 : 2 : 6 | 1 : 2 | 1 : 2½ |

The non-alkaline protoxyd is lime; the alkaline is soda with some potash. The excess of silica in Mizzonite and Marialite may be attributable to impurity or alteration as has been usual (and to some extent with reason) in the Scapolite division of the Scapolite group. But the crystals are glassy and show no evidence of change or mixture. They are found exclusively in volcanic or allied igneous rocks.

C. The Scapolite section of the Scapolite group affords other examples under the principle. The different compounds vary in oxygen ratio, according to the analyses, from 1 : 2 : 3·5 to 1 : 2 : 6, and from 1 : 3 : 4 to 1 : 3 : 6; and besides these there are other ratios intermediate. But Scapolite undergoes so easy alteration through the action of carbonated or alkaline waters that we have reason for doubts over many of the results of analyses.* Yet, in spite of the uncertainties from this source the principle stated comes out clearly to view. In fact it has already been remarked by Rammelsberg in his Mineral Chemie (p. 716) that "the Scapolites which are poorest in silica are richest in lime; and as the lime diminishes, the proportion of soda (or potash) increases."

Looking first at the prominent divisions, we find the following as the average ratios afforded by the best analyses.†

* Scapolite undergoes easy alteration through carbonated waters, which make the lime a carbonate; through solutions of a potash salt, which substitute potash for the soda; and through solutions of an iron salt, which introduce oxyd of iron. Vom Rath describes mica, epidote, agalmatolite, and other pseudomorphs, after scapolite. In changing to mica, potash and iron were taken up, and soda lost; to epidote, oxyd of iron (15 to 16 p. c.) was taken and part of the silica lost; to agalmatolite, potash (7 p. c.) displaced soda, and water was taken in, and moreover, part of the lime became carbonated. Similar altered scapolites have been described by others. It is rather probable that the trace of potash found in many scapolites is always a result of change.

Couzeranite has been placed near dipyre in the table on p. 404. But it contains 5·5 p. c. of potash, and is, with hardly a doubt, an altered mineral.

Eichhorn has shown (Pogg., cv. 126) that, by subjecting chabazite to the action of a cold solution of chlorid of sodium or carbonate of soda, 6 to 8 p. c. of soda may be substituted in the mineral for an equivalent of lime; and it may be that scapolite by this or other means may have its proportion of soda increased.

† The names *Wernerite* and *Scapolite* were given to Norwegian minerals from Arendal) by d'Andrada in the same article, (in Scherer's J., iv, 35, 38, 1800). *Scapolite* is needed as a name for the whole *group*, like Feldspar, Mica, Chlorite, for corresponding groups of species, and is therefore here thus employed. *Wernerite* is applied to one of the two most prominent sections; *Ekebergite* to the other, it including the variety so-called; while Haüy's name paranthine, changed to *paranthite*, is adopted for the first of the sections. The composition of the first section was long ago the supposed composition (after Laugier's analysis) of the Arendal paranthine or scapolite.

| | Ṙ Ṙ Si | Bases : Silica | Non-alk. : Alk. |
|---|---|---|---|
| 1. Paranthite | 1 : 2 : 4½ | 1 : 1½ | 2½ : 1 |
| 2. Wernerite | 1 : 2 : 4 | 1 : 1⅓ | 4 : 1 |
| 3. Ekebergite | 1 : 3 : 4 | 1 : 1 | all non-alk. |
| 4. Dipyre | 1 : 2 : 6 | 1 : 2 | 1 : 1 |

As a fuller exposition of the facts, the ratios for the more satisfactory analyses, from which the above mean results have been deduced, are given in the table following. The numbering of the analyses in Rammelsberg's work is added for the convenience of reference.*

| A. | Ṙ Ṙ Si | Bases | Silica | Non-alk. : Alk |
|---|---|---|---|---|
| 1, Pargas Storgard, Nordenskiöld | 1 : 2·6 : 3·6 | 1 : 1·00 | | All non-alk. |
| 4, Tunaberg, *trl.* Walmst. | 1 : 3 : 4·2 | 1 : 1·05 | | " " |
| 3, *a* " *trl. cryst.*, Nord. | 1 : 3 : 4·3 | 1 : 1·06 | | " " |
| 3, *b* Pargas, Ersby, *cryst.* Nord. | 1 : 3·1 ; 4·4 | 1 : 1·07 | | " " |
| 7, Pargas (Ersby?) *cryst.*, Wolff | 1 : 2·9 : 4·5 | 1 : 1·16 | | 17 : 1 |
| B | | | | |
| 8, Pargas, Ersby, v. Rath | 1 : 2·5 : 4·2 | 1 : 1·20 | | 6·15 : 1 |
| 9, Arendal, *mass.*, v. Rath | 1 : 1·7 : 3·4 | 1 : 1·24 | | 2·65 : 1 |
| 11, " *cryst.*, v. Rath | 1 : 1·8 : 3·6 | 1 : 1·27 | | 5·45 : 1 |
| 16, L. Baikal, *Glaucolite*, v. Rath | 1 : 2·1 : 4 | 1 : 1·28 | | 3·90 : 1 |
| 15, Bolton, *pink*, Wurtz | 1 : 1·8 : 3·7 | 1 : 1·30 | | 2·50 : 1 |
| 13, " Thomson | 1 : 2·0 : 4·0 | 1 : 1·33 | | 5·70 : 1 |
| 14, Drothems, *pink*, Berg. | 1 : 2·0 : 4·0 | 1 : 1·33 | | 4·03 : 1 |
| 22, Bolton, *pink*, Wolff | 1 : 2·2 : 4·3 | 1 : 1·35 | | 3·84 : 1 |
| 17, Malsjö, *blue mass.*, v. Rath | 1 : 1·7 : 4·0 | 1 : 1·38 | | 5·36 : 1 |
| 18, Finland, *gnh.*, Wolff | 1 : 1·9 : 4 | 1 : 1·38 | | 3·98 : 1 |
| C. | | | | |
| 25, Malsjö, *pink*, etc., Wolff | 1 : 2·1 : 4·4 | 1 : 1·42 | | 1·89 : 1 |
| 24, Pargas, *Ekebergite*, Hartw. | 1 : 2 : 4·3 | 1 : 1·43 | | 3·05 : 1 |
| 23, Hesselkulla, mass., Wolff | 1 : 2·2 : 4·5 | 1 : 1·44 | | 2·45 : 1 |
| 28, Hesselkulla, Herm. | 1 : 2·5 : 5·1 | 1 : 1·46 | | 3 : 1 |
| 27, Arendal, Wolff | 1 : 2·1 : 4·5 | 1 : 1·47 | | 2·06 : 1 |
| Arendal, Damour | 1 : 2·1 : 4·7 | 1 : 1·50 | | 2·35 : 1 |
| 26, Malsjö, *white*, v. Rath | 1 : 2·1 : 4·6 | 1 : 1·50 | | 2·28 : 1 |
| 35, Gouverneur, *cryst.*, v. Rath | 1 : 2 : 5 | 1 : 1·65 | | 1·24 : 1 |
| D. | | | | |
| *Couzeranite*, Dufrénoy | 1 : 2·3 : 5·8 | 1 : 1·74 | | 1·32 : 1 |
| *Dipyre*, Delesse | 1 : 2·0 : 5·8 | 1 : 1·71 | | 1·02 : 1 |
| *Dipyre*, Damour | 1 : 2·2 : 6·0 | 1 : 1·92 | | 1·26 : 1 |
| *Dipyre*, Pisani | 1 : 2·3 : 6·5 | 1 : 2 | | 0·95 : 1 |
| *Prehnitoid*, Blomstrand | 1 : 2 : 5·7 | 1 : 1·89 | | 0·80 : 1 |

The four groups A, B, C, D, correspond to those above named *Paranthite*, *Wernerite*, *Ekebergite*, and *Dipyre*. Analysis No. 9, of an Arendal Scapolite diverges rather widely from the mean of the group; but the specimen was probably an abnormal one in some way, as the results are quite unlike those obtained from Arendal specimens by Wolff and Damour (No.

* The analyses omitted are those which are doubtful because containing carbonate of lime; those (as No. 30 by Brewer, 38 by v. Rath, etc.) which were published as analyses of *altered* scapolites; those of little hardness, thereby evincing alteration; the analyses of glaucolite by Bergemann and Givartovski, the mineral for which v. Rath has shown is of uncertain nature, and not true glaucolite.

27 and the one next following). With this exception, and that of Wurtz's (No. 15) which is not sustained in its exceptional character by Wolff's, (No. 22) of the same mineral, nor by a new determination by B. S. Burton, the concordances with the principle stated are close, considering the uncertainties of analyses, and the uncertain purity or condition of specimens.

D. Among the Bisilicates, occurs the species *Spodumene*. It is so closely like pyroxene in angles, and also in habit of crystals and physical characteristics, that it is rightly placed in the pyroxene group. It has the oxygen ratio for the protoxyds, sesquioxyds, and silica 1 : 4 : 10; whence 5 : 10=1 : 2 for the bases and silica, as in other Bisilicates. Its protoxyd bases are mainly alkaline, the proportion of alkaline to non-alkaline averaging 12 : 1 in the best analyses—those of Rammelsberg and Hagen (the extremes being 4 : 1 and 20 : 1), and those of Smith & Brush (which give 11 : 1 and 13 : 1). There is some iron present which is here made protoxyd as done by Rammelsberg. Descloizeaux has shown that *Petalite*, is also like pyroxene, in crystallization, and in this and other characters, approaches Spodumene. It contains, like it, silica, alumina, lithia, and soda; but the oxygen ratio is 1 : 4 : 20, the silica being doubled, as remarked by Descloizeaux. There is this other difference that the protoxyd bases are *exclusively* alkaline; no iron is present either as protoxyd or sesquioxyd. This increase of the silica by a simple ratio is evidently parallel with the same in the Feldspar and Mica groups. And since both Spodumene and Petalite occur in granitic rocks, or those of extreme metamorphism, and therefore of like heat in origin, and as the Spodumene is often imbedded in free quartz, showing that there was no lack of silica at its formation, it would appear that the small difference of constitution as to the bases, above pointed out, determines the proportion of silica. It is quite possible that iron may have the same influence as the non-alkaline metals even if it replace alumina.*

From the above examples it seems to follow, first, that under

* Another probable example under the principle is that of *Leucophane*, and the Chrysolite group. Chrysolite has a vertical prism of 94° 3′, with a macrodome of 76° 54′. Leucophane, also orthorhombic, has the corresponding angles 91° to 93°, and 72° 50′; there is, hence, approximate isomorphism. In both, moreover, the bases are all protoxyds; and as respects habit and physical characters, they may well be related species. Now Chrysolite is a normal Unisilicate, the oxygen ratio, for bases and silica being 1 : 1, and it contains no alkalies. While Leucophane has a large excess of silica, the oxygen ratio being 1 : 1⅓ instead of 1 : 1, and, *correspondingly, it contains* 10 *to* 11 *p. c. of soda.*

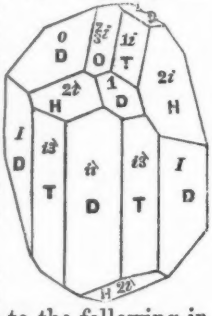
Again, *Meliphane* (melinophane) appears to bear the same relation in form and constitution to phenacite, as Leucophane to Chrysolite. [The name *melinophane* is wrong and bad, the Greek signifying either *ash-* or *millet-like*, instead of *honey-like* as its author intended. It should be *melitophane* or meliphane.]

both the Unisilicate and Bisilicate type, there is some principle on which the proportion of silica may increase without changing the type; secondly, that this increase accompanies increase in the proportion of the alkalies, (or the perissad metals) and is probably more promoted by K̇ than Ṅa; thirdly that this excess of silica occurs without a change of the type of the species from that of the Unisilicate or Bisilicate; and that the surplus silica is either accessory silica, or part of it basic.*

## 2. *Isomorphism of the Isometric and Clinohedral Feldspars.*

Although Leucite belongs apparently to a different series in the Feldspar group from the clinohedral (monoclinic and triclinic) species, and its trapezohedral form has seemingly very little resemblance to the oblique prisms of the other Feldspars, the monoclinic crystals of orthoclase and the triclinic of anorthite etc., are in fact nothing but distorted, or rather, *clinohedrized dodecahedrons*, variously modified by cubic, octahedral, trapezohedral and other planes.

In Orthoclase this clinohedrism consists (*a*) in giving the dodecahedron an obliquity in one direction of about 8 degrees, one of its octahedral axes, thus inclined in a vertical plane parallel to a pair of dodecahedral planes, becoming the vertical axis; and (*b*) slightly shortening this axis; and for the triclinic forms, it is nearly the same, excepting that the obliquity extends to the vertical plane referred to, and consequently to the planes about it.




The annexed figure represents a common form of Orthoclase, copied from Naumann's crystallography. The lettering corresponds to the following in Naumann, and Brooke and Miller:

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Naumann | *O* 0P *P* | *I* ∞P *T,l* | *i-i* [∞P∞] *M* | *i-3* [∞P3] *z* | $\frac{3}{2}$-*i* $\frac{3}{2}$P∞ *q* | 1-*i* P∞ *x* | 2-*i* 2P∞ *y* | 1 P *o* | 2-*i* [P∞] *n* |
| Brooke & Miller | 001 *c* | 110 *m* | 010 *b* | 130 *z* | 203 *q* | 101 *x* | 201 *y* | 111 *o* | 021 *n* |

The prismatic angle of the crystals is 118° 48′ or near 120°; and the same angle in Albite is 120° 47′; in Oligoclase 120° 42′; in Labradorite 121° 37′; in Anorthite 120° 30′.

* *Errata.*—In these articles, this volume, p. 93, 14 l. fr. foot, for $\frac{1}{3}$ read $\frac{2}{3}$; 10 l. and 13 l. fr. foot, for $\delta$ read $\varepsilon$, and for $\varepsilon$ read $\delta$. Page 253, for $RO^5$ read $R^2O^5$; for $5R\frac{1}{3}O$ read $5R\frac{2}{3}O$; for $R_{\frac{1}{3}}$, $R_{\frac{1}{8}}$, $R_{\frac{1}{5}}$, read $R_{\frac{1}{2}}$, $R_{\frac{2}{3}}$, $R_{\frac{1}{8}}$; for $\delta$ read $\varepsilon$, and for $\varepsilon$ read $\delta$. Page 255, 9 l. fr. foot, p. 258, 8 l. fr. top, p. 259, 2 l. fr. top, for $\delta$ read $\varepsilon$.

In order to appreciate the following comparisons, the reader should have before him a dodecahedral crystal, (of garnet, for example,) or a model of the form, placed with a trihedral angle at top, and with one face of the trihedral pyramid sloping to the left; in which position it is a 6-sided prism with trihedral summits, with its planes parallel to those of the figure.

The prismatic angle of the feldspars, as in many other minerals, is very closely the angle of the dodecahedron (120°); and the four planes *I* enclosing it correspond therefore to four of the vertical faces of this dodecahedron; while the two planes *i*-$\bar{\imath}$ which make angles with *I* of 120° 26′, are the other two.

The basal plane *O* is another dodecahedric plane; for $O : I = 122° 16'$; and $O : i\text{-}\bar{\imath} = 90°$, the exact dodecahedral angle. This makes *eight* out of the twelve.

The four planes 1, are also dodecahedric. This might be inferred from their position as referred to a model dodecahedron. It is also apparent in the angles which the planes make with one another and with the planes just shown to be dodecahedric, namely *O*, *I*, and *i*-$\bar{\imath}$; for $1 : 1 = 126° 14'$, $O : 1 = 124° 42'$, $i\text{-}\bar{\imath} : 1 = 116° 53'$, the mean of which is nearly 120°. The divergence from 120° is due to the 8° of obliquity which the dodecahedral form has in orthoclase. Thus *all the twelve faces of the dodecahedron* exist on the crystal of orthoclase in the figure here presented. They are lettered **D**.

Moreover the *cleavage* in orthoclase according to this result is dodecahedric, it being parallel to *O* and *i*-$\bar{\imath}$, which planes are at right angles both in orthoclase and the dodecahedron.

The plane *i*-3′ replaces an edge between *I* (**D**) and *i*-$\bar{\imath}$ (**D**); making the angle $= i\text{-}\bar{\imath} : i\text{-}3' = 150° 35'$. The planes *i*-3′ are therefore those of the *trapezohedron* 2-2, which truncate the edges of the dodecahedron, and make with the dodecahedral planes the angle 150°; they are therefore lettered **T**. The plane 1-*i* truncates the edge between 1 and 1, other planes **D** (dodecahedric), and therefore this also is a trapezohedric plane, and is lettered **T**; it makes with each plane 1 the angle 153° 7′ (which is near 150°); and with O (**D**), over the plane $\frac{3}{3}$-*i* (**O**), the angle 129° 41′, the corresponding isometric angle being 125° 16′. The crystal therefore contains six faces of the trapezohedron 2-2.

Again 2-$\bar{\imath}$ are faces of the cube (or hexahedron), and are therefore lettered **H**; the angle *O* (**D**) : 2-$\bar{\imath} = 135° 3'$ while the corresponding isometric angle is 135° Referred to the model dodecahedron, it truncates the tetrahedral solid angles. Again 2-*i* has the position of a plane truncating another tetrahedral solid angle of the dodecahedron, and is also a face of a cube, and is lettered **H**. The angle *I* (**D**) : 2-*i* = 134° 19′ or very nearly

135° the angle between a face of a cube and a plane truncating its edges.

The plane $\frac{2}{3}$-$i$, at the top of the figure, the only remaining one, is a face of the *octahedron*,—a plane which on the dodecahedron truncates its trihedral solid angles,—and it is therefore lettered **O**. The angle $I$ (**D**) : $\frac{2}{3}$-$i$ = 145° 47′, while the angle between a dodecahedral and octahedral plane, is 144° 44′. The angle 2-$i$ (**H**) : $\frac{2}{3}$-$i$ = 124° 51′, while the angle between a cubic and octahedral plane is 125° 16′. That the plane is octahedric is further apparent from the parallel intersections of $\frac{2}{3}$-$i$, 2-$\breve{\imath}$, $i$-3$\breve{}$, and of $O$, $\frac{2}{3}$-$i$, 2-$i$; for (1) a cubic face makes parallel intersections between an octahedral on one side (the trapezohedral on that side being absent) and a trapezohedral on the other; and (2) an octahedral face makes parallel intersections with a cubic on one side and a dodecahedral on the other.

The form of orthoclase is therefore strictly a clinohedrized dodecahedron. The faces present in the crystal here considered, are

The *dodecahedric*, $I, I, i$-$\breve{\imath}$, $O$, 1, 1, with their opposites, or *the whole twelve*.

The *trapezohedric*, 1-$i$, $i$-3$\breve{}$, $i$-3$\breve{}$, with their opposites, or *six* in all.

The *octahedric*, $\frac{2}{3}$-$i$, with its opposite, or *two*.

The *cubic*, 2-$\breve{\imath}$, 2-$\breve{\imath}$, 2-$i$, with their opposites, or *the whole six*. The angles of this oblique or clinohedrized cube are 2-$\breve{\imath}$ : 2-$\breve{\imath}$ over $O$ = 90° 6′, 2-$\breve{\imath}$ : 2-$i$ = 96° 48′.

The true or normal apex of the orthoclase dodecahedron is that part of the crystal occupied by the octahedric plane $\frac{2}{3}$-$i$; and the true obliquity of the crystal (or angle C,) instead of being 63° 53′ and 116° 7′ (or the angle $O$ : $i$-$i$) would be the angle $\frac{2}{3}$-$i$ : $i$-$i$, which equals 81° 54′ and 98° 06′. Hence 8° 6′ is the extent to which the octahedron has been clinohedrized in its conversion into the form of orthoclase.

For the triclinic feldspars, the only peculiarity is that already mentioned,—the fact of lateral obliquity of the principle section, so that the two cleavage planes O, $i$-$\breve{\imath}$ (dodecahedric planes on opposite sides of a tetrahedral solid angle) make with one another an angle of 93° 15′ to 94° 15′ instead of 90°. The form of the crystals are so similar to those of orthoclase, with this exception, that special explanations are unnecessary.

G. Rose, in a recent article on Albite (Pogg., cxxv, p. 457), observes (p. 466), that it is a remarkable fact that the planes 2-$\breve{\imath}$ situated either side of $O$, between it and $i$-$\breve{\imath}$, (planes $e$ and $n$ of Rose,) make with one another in albite very nearly a right angle, 90° 35′ according to Neumann, and 90° 4′ according to DesCloizeaux's measurements. It is not so surprising

when it is understood that the two planes 2-$\breve{i}$ in albite are *cubic* faces.

In addition to the above dodecahedric characteristics of the crystals of the Feldspar group, it may be added that the twins are twinned parallel either to dodecahedric or cubic faces. The most common in orthoclase are those parallel to *i*-$\breve{i}$, dodecahedric; others are twinned parallel to *O*, also dodecahedric; others parallel to 2-$\breve{i}$, or a cubic face. And there are no other directions of twinning among the *triclinic* feldspars.

In another number of this Journal I propose to consider further the isometric relations of the various systems of crystallization, a subject partly elucidated in the last edition of my Mineralogy (1854, vol. i, pp. 196–204), and also in this Journal for the same year, vols. xvii, and xviii.

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ART. XLV.—*On certain points in the theory of Atomicities;* by WOLCOTT GIBBS, M.D., Rumford Professor in Harvard University.

IN the application of the theory of atomicities to the explanation of the formation and structure of compound bodies two distinct views are held by chemists. While Kekulé and his followers maintain that the primary or essential atomicity of each element is invariable, Wurtz, Frankland and others admit that an element may have more than one degree of saturating power, Wurtz in particular assigning no specific maximum or limit in any case. The chemists of both these schools distinguish between atomic and molecular combinations, differing only as to what combinations are to be regarded as molecular. Thus according to Kekulé pentachlorid of phosphorus is a molecular compound, $P^{III}Cl_3+Cl_2$, while upon the other view it is atomic and has the formula $P^{V}Cl_5$. All chemists appear to admit that water of crystallization is in molecular and not in atomic combination.

To this view it may be reasonably objected that it creates two distinct species of chemical affinity, for if phosphorus in the terchlorid is saturated and its three units of affinity satisfied, a new force must be called in to bind the two additional atoms of chlorine which are to form the pentachlorid, and if chlorid of sodium be a saturated atomic combination, by what force does it unite with two atoms of water to form $NaCl+2H_2O$? The line which this theory draws between molecular and atomic combinations is, moreover, a purely arbitrary one, as is clearly seen in the case of the chlorids of phosphorus cited above. In

the present paper I shall endeavor to show that the assumption of a particular class of molecular compounds is unnecessary, and that all compounds may be regarded as essentially atomic. I adopt the following postulates no one of which is new.

1. The elements may be divided into two classes; those whose primary or inherent atomicities are represented by odd, and those whose atomicities are represented by even numbers.

2. The atomicities are variable and no maximum or limit can be assigned in any case. Any element of the first class may therefore be 1, 3, 5, 7, &c., atomic, and any element of the second class 2, 4, 6, 8, &c., atomic.

3. In the combinations of an element with itself or with another element a certain number of units of atomicity disappear. The atomicity of the resulting compound will be termed *secondary*.

For the sake of convenience I shall give the name of *determinant* to the dominant element in any compound, the other elements being termed *sub-determinants* or *subjects*, while the compound itself is termed the *resultant*. Thus in ammonia, $N\left\{\begin{matrix}H\\H,\\H\end{matrix}\right.$ nitrogen is the determinant, and hydrogen the subject, while in nitrid of copper, $N_2\left\{\begin{matrix}Cu\\Cu,\\Cu\end{matrix}\right.$ copper is the sub-determinant. In borid of nitrogen, $B^{III}N^{III}$, either element may be taken as the determinant. According to this view ammonia may be regarded as the product of a single action, that, namely, of nitrogen upon hydrogen, while in nitrid of copper there are two actions, the duplication of the atom of nitrogen being due to the diatomic character of the copper.

If now we consider first the case of water, $OH_2$, it is easy to see that if oxygen be regarded as tetratomic or at least as having an even atomicity higher than 2, water will itself be weakly diatomic, whatever may be the number of atoms of this body in a given compound. For in $O^{IV}H_2$ it is clear that only two units of affinity are saturated. Morever, in any number of atoms of water two units will vanish for every atom with the exception of the first and last, in each of which one unit only will disappear. Graphically this may be represented as follows:

—○—○—○—○—○—○—

From this it appears that the atomicity of the water of crystallization in a salt may always be considered as 2, whatever be the number of atoms. In like manner it is easily seen that ammonia, $N^VH_3$, is diatomic, and that any number of associated atoms of ammonia will still, as a whole, represent only a single diatomic atom.

With these preliminaries I shall consider in order a few cases of what is termed molecular union.

Since sodium may be regarded as feebly triatomic it follows that in chlorid of sodium, $Na^{III}Cl$, there are still two units of affinity unsaturated, the intensity of the affinity being very small. Hence the salt, $Na^{III}Cl+(2\Theta H_2)''$, in which the sodium may be regarded as saturated, exists only at low temperatures. In sodic sulphate we may for convenience take sulphur as the determinant, in which case the salt will have the formula, $S^{IV}\left\{\begin{matrix}\Theta_2\\(Na\Theta)_2\end{matrix}\right.$ considered as anhydrous. But the crystallized salt contains ten atoms of water and may be written $S^{VI}\left\{\begin{matrix}\Theta_2\\(Na\Theta)'_2\\(\Theta H_2)''_{10}\end{matrix}\right.$ to exhibit the manner in which the water of crystallization completes the saturation of the hexatomic sulphur.

Trisodic ortho-phosphate contains twelve atoms of water, and if we take phosphorus as the determinant may be written

$$P^{VII}\left\{\begin{matrix}\Theta^{II}\\(Na\Theta)_3\\(\Theta H)''_{12}\end{matrix}\right.$$

phosphorus being heptatomic.

These formulas will suffice to exhibit the application of the theory to cases in which water of crystallization is present. To avoid complication in expression it would perhaps be more convenient to indicate the subordinate atomicity by Roman numerals placed beneath the symbol of the determinant and to connect the water of crystallization in the usual manner by the sign +. Thus sodic sulphate may be written

$$\begin{matrix}IV\\S\\II\end{matrix}\left\{\begin{matrix}\Theta_2\\(Na\Theta)_2\end{matrix}\right. +10aq$$

which exhibits at once both degrees of atomicity.

The views above explained enable us to formulate as atomic compounds the very numerous class of so-called double haloid salts usually regarded as molecular. Thus acid fluorid of potassium, KF+HF, becomes

$$\left.\begin{matrix}K^{III}F_2\\H\end{matrix}\right\} \text{ or } K\,(H^{III}F_2)$$

which may be compared directly with hydrate of potash

$$\left.\begin{matrix}K^{III}\Theta^{II}\\H\end{matrix}\right\} \text{ or } K(H^{III}\Theta).$$

The so-called double fluorids of tin, zirconium and silicon may readily be reduced to the following types in which in each case the tetratomic element is taken as the determinant.

$SnF_4+2KF$ $\qquad Sn\left\{\begin{matrix}F_2\\(KF_2)_2\end{matrix}\right.$

$SnF_4+3KF+HF$, $Sn\left\{\begin{matrix}3(KF_2)\\(HF_2)'\end{matrix}\right.$

$ZrF_4+3CuF$, $''Zr^{iv}\left\{\begin{matrix}''Zr^{iv}\\3(CuF_4)''\end{matrix}\right.$

$SnF_4+4NH_4F$ $Sn\left\{4(NH_4F_2)\right.$

$SnF^4+BaF$ $Sn\left\{\begin{matrix}F_2\\(Ba^{vi}F_4)''\end{matrix}\right.$

$2ZrF_4+2KF+NiF_2'$ $''Z^{iv}{}_r\left\{\begin{matrix}Z^{iv}{}_r\\(KF_2)''_2(NiF_4)''\end{matrix}\right.$

$ZrF_4+2NiF_2$ $Zr\left\{2(NiF_4)''\right.$

$2ZrF_4+5NaF$ $''Zr^{vi}\left\{\begin{matrix}''Zr^{vi}\\(NaF_2)_5(F)_3\end{matrix}\right.$ $ZrF_4+4KF$ $Zr\left\{(KF_2)_4\right.$

$ZrF_4+3KF$ $Zr\left\{\begin{matrix}(KF_2)_3\\F\end{matrix}\right.$ $SiF_4+2KF$ $Sn\left\{\begin{matrix}(KF_2)_2\\F_2\end{matrix}\right.$

$ZrF_4+KF$ $Zr\left\{\begin{matrix}(KF_2)\\F_3\end{matrix}\right.$

The compounds of the fluorids of tantalum, niobium, arsenic and antimony with other fluorids may be reduced to the following types, taking the pentatomic element as the determinant, and as before omitting water of crystallization for the sake of simplicity.*

$TaF_5+2KF$ $Ta\left\{\begin{matrix}F_3\\(KF_2)_2\end{matrix}\right.$ $NbO_2F_3+2KF$ $Nb\left\{\begin{matrix}O\\F\\(KF_2)_2\end{matrix}\right.$

$NbF_5+2KF$ $Nb\left\{\begin{matrix}F_3\\(KF_2)_2\end{matrix}\right.$ $NbO_4F_3+3KF$ $Nb\left\{\begin{matrix}O\\(KF_2)_3\end{matrix}\right.$

$NbOF_3+3KF+HF$ $Nb\left\{\begin{matrix}F\\(HO)\\(KF_2)_3\end{matrix}\right.$

$3NbOF_3+5KF$ $\left.\begin{matrix}''Nb^{vii}\\''Nb^{vii}\\''Nb^{vii}\end{matrix}\right\}O_3(KF_2)_5F_4$

$3NbOF_3+4KF$ $\left.\begin{matrix}''Nb^{vii}\\''Nb^{vii}\\''Nb^{vii}\end{matrix}\right\}O_3(KF_2)_4F_5$

$NbOF_3+ZnF_2$ $Nb\left\{\begin{matrix}O\\F\\(ZnF_4)''\end{matrix}\right.$

$SbF_5, KF$, $Sb\left\{\begin{matrix}F_4\\(KF_2)'\end{matrix}\right.$ $SbF_5, 2KF$, $Sb\left\{\begin{matrix}F_3\\(KF_2')_2\end{matrix}\right.$

* It must be remarked that in the comparative formulas given above the symbols of the elements in the expressions on the left hand usually, when not barred, signify the old equivalent, while in those on the right they signify atoms. The want of type for all the barred letters is the occasion of this confusion which I hope will be excused.

$$SbOF_3,\quad NaF, Sb\left\{\begin{matrix}O\\(NaF_2),\\F_2\end{matrix}\right.\quad As_2OF_8,\ 4KF,\quad \begin{matrix}''As^{vii}\\''As^{vii}\end{matrix}\left\{\ (KF_2)_4OF_4\right.$$

Finally the two remarkable salts discovered by Briegleb and which are represented empirically by the formulas

$$PO_4Na_3+NaF+12aq \text{ and } AsO_4Na_3+NaF+12aq$$

may at once be reduced to the normal pentatomic type as follows:

$$P^v\left\{\begin{matrix}(NaO)_4\\F\end{matrix}\right.+12aq, \text{ and } A^vs\left\{\begin{matrix}(NaO)_4\\F\end{matrix}\right.+12aq.$$

It is to be remarked that in two of the above formulas, niobium, and in one arsenic, is represented as heptatomic. In these cases each atom of niobium, or of arsenic, loses two units of affinity in combining with an associate atom of the same elements. The notation employed in this and similar cases is that of Frankland.

From the double fluorids so-called, I pass to the consideration of the double chlorids, which, as is well known, are very numerous.

A glance at the following formulas will show the application of the principles which I have laid down to this class of compounds.

$$HgCl_2+MnCl_2 \qquad Hg^{ii}\left\{\ (Mn^{vi}Cl_4)''\right.$$

$$2HgCl_2+BaCl_2 \qquad \begin{matrix}''Hg^{iv}\\''Hg^{iv}\end{matrix}\left\{\ Ba^{vi}Cl_4)''(Cl)_2\right.$$

$$5HgCl_2+CaCl_2 \qquad \left.\begin{matrix}''Hg^{iv}\\''Hg^{iv}\\''Hg^{iv}\\''Hg^{iv}\\''Hg^{iv}\end{matrix}\right\}(CaCl_4)''Cl_8$$

$$2KCl+HgCl_2 \qquad Hg^{ii}(KCl_2)_2$$

$$KCl+HgCl_2 \qquad Hg^{ii}(KCl_2)Cl$$

$$KCl+2HgCl_2 \qquad \begin{matrix}''Hg^{iv}\\''Hg^{iv}\end{matrix}\left\{\begin{matrix}(KCl_2)\\Cl_3\end{matrix}\right.$$

$$MgCl_2+3HgCl_2 \qquad \left.\begin{matrix}''Hg^{iv}\\''Hg^{iv}\\''Hg^{iv}\end{matrix}\right\}(MgCl_4)''Cl_4$$

$$PtCl_4+2KCl \qquad Pt\left\{\begin{matrix}Cl_2\\(KCl_2)_2\end{matrix}\right.$$

$$PtCl_4+BaCl_2 \qquad Pt\left\{\begin{matrix}Cl_2\\(BaCl_4)''\end{matrix}\right.$$

$$PtI_4+2HI \qquad Pt\left\{\begin{matrix}I_2\\(HI_2)_2\end{matrix}\right.$$

$$Ir_2Cl_6+4KCl \qquad \begin{matrix}'Ir^{iv}\\'Ir^{iv}\end{matrix}\left\{\ (KCl_2)_4Cl_2\right.$$

$Ir_2'Cl_6+6KCl$ $\quad {}'Ir^{iv}{}_2{}'Ir^{iv}{}_2\left\{(KCl_2)_6\right.$

$U_2\Theta_2Cl_2+2KCl$ $\quad {}''U^{iv}{}''U^{iv}\left\{\begin{matrix}\Theta_2\\(KCl_2)_2\end{matrix}\right.$

$AuCl_3+KCl$ $\quad Au^{iv}\left\{\begin{matrix}Cl_2\\(KCl_2)\end{matrix}\right.$

$2AuCl_3+BaCl_2$ $\quad {}''Au^{v}{}''Au^{v}\left\{\begin{matrix}Cl_4\\(BaCl_4)''\end{matrix}\right.$

$W\Theta_4K_2+WF_8K_2$ $\quad W^{vi}\left\{\begin{matrix}\Theta_2\\(KF_2)_2\end{matrix}\right.$ like $W^{vi}\left\{\begin{matrix}\Theta_2\\(K\Theta)_2\end{matrix}\right.$

$W\Theta_2F_3K$ $\quad W^{vi}\left\{\begin{matrix}\Theta_2\\F\\(KF_2)\end{matrix}\right.$

$W\Theta_2CuF_4$ $\quad W^{vi}\left\{\begin{matrix}(Cu\Theta_2)''\\F_4\end{matrix}\right.$

$W\Theta_2CuF_4+NH_4F$ $\quad W^{vi}\left\{\begin{matrix}(Cu\Theta_2)''\\(NH_4.F_2)\\F_3\end{matrix}\right.$

The principle of variable atomicity enables us also to formulate a great variety of other compounds which have hitherto been considered as molecular. As the application is sufficiently evident after what has been said, I shall content myself with a few examples only.

All combinations of metallic chlorids, &c., with ammonia may be formulated atomistically if it be admitted that $n$ atoms of ammonia are as a whole simply diatomic. Thus we have

$TiCl_4+4NH_3$ $\quad Ti^{vi}\left\{\begin{matrix}Cl_4\\(4NH_3)''\end{matrix}\right.$

Chlor. of Roseocobalt, $Co_2Cl_6+10NH_3$ $\quad {}''Co^{vi}{}''Co^{vi}\left\{Cl_6(10NH_3)''\right.$

Chlor. of Luteocobalt, $Co_2Cl_6+12NH_3$ $\quad {}''Co^{vi}{}''Co^{vi}\left\{Cl_6(12NH_3)''\right.$

Chlor. of Xanthocob't, $Co_2\Theta Cl_2+N_2\Theta_3+10NH_3$ $\quad {}''Co^{vi}{}''Co^{vi}\left\{\Theta_2Cl_2(N_2\Theta_3.10NH_3)''\right.$

Sulph. of Roseocobalt, $Co_2(S\Theta_4)_3+10NH_3$ $\quad {}''Co^{vi}{}''Co^{vi}\left\{(S\Theta_4)''_3(10NH_3)''\right.$

Sulph. of Luteocobalt, $Co_2(S\Theta_4)_3+12NH_3$ $\quad {}''Co^{vi}{}''Co^{vi}\left\{(S\Theta_4)''_3(12NH_3)''\right.$

Sulph. of Xanthocob't, $Co_2(S\Theta_4)_3+N_2\Theta_3+10NH_3$ $\quad {}''Co^{vi}{}''Co^{vi}\left\{\begin{matrix}\Theta''(S\Theta_4)''_3\\(N_2\Theta_3.10NH_3)''\end{matrix}\right.$

Gros' base, $PtCl_2N_4H_{12}\Theta$ $\quad Pt^{vi}\left\{Cl_2(4NH_3)''\Theta''\right.$

Reiset's base No. 1, $PtN_4H_{12}\Theta$ $\quad Pt^{iv}\left\{(4NH_3)''\Theta''\right.$

" " No. 2, $PtN_2H_6\Theta$ $\quad Pt^{iv}\left\{(2NH_3)''\Theta''\right.$

Raewsky's base No. 1, $Pt_2Cl_2\Theta_3H_{24}\Theta_2N_8$ $\quad {}^{\prime}Pt^{iv}\left\{ {}^{\prime}Pt^{iv}\right\}Cl_2\Theta_5(8NH_3)''$

" " No. 2, $Pt_2Cl_4\Theta_4H_{24}\Theta_2N_8$ $\quad {}^{\prime\prime}Pt^{vi}\left\{ {}^{\prime\prime}Pt^{vi}\right\}Cl_4\Theta_6(8NH_2)''$

If it be objected to the assumption that potassium, sodium, &c., are triatomic in certain combinations, that these elements have not yet been observed to form compounds with chlorine and other usually monatomic elements of the form $K\left\{\begin{matrix}Cl\\Cl\\Cl\end{matrix}\right.$, I reply first that thallium, which unquestionably belongs to the alkaline group, is distinctly triatomic in $TlCl_3$, and secondly that if chlorine itself be sometimes triatomic, the compound KCl may be represented as $K^{'''}Cl^{'''}$ as well as $K^{'}Cl^{'}$, each element being saturated upon either view. With respect to the elements belonging to the nitrogen group I will simply call attention to the fact that nitrogen is heptatomic in the hyperiodids of certain complex ammoniums and enneatomic in others. Thus we have

$$N\left\{\begin{matrix}(CH_3)_4\\I_3\end{matrix}\right., \quad \text{and} \quad N\left\{\begin{matrix}(CH_3)_4\\I_5\end{matrix}\right.,$$

so that nitrogen furnishes the most complete series of atomicities, being 1, 3, 5, 7 and 9-atomic.

It is easily seen that there is a marked difference between the elements both of odd and of even atomicities as regards the maximum intensity of combining power. Thus potassium, sodium, hydrogen, chlorine and some other elements have their maximum of affinity with an atomicity of unity, the affinity being very much less for an atomicity of three and insensible for higher atomicities. Nitrogen, phosphorus, boron and several others have an insensible affinity for an atomicity of unity; the intensity of their affinity becomes a maximum when they are triatomic, diminishes materially when they become pentatomic, and becomes nearly insensible when they are heptatomic. Finally, tantalum and niobium have their maximum intensity of combining power with an atomicity of five. Precisely analogous differences occur with the elements of even atomicity. We are not yet in a position to determine whether the combination of two or more atoms of water, of ammonia, or in general of any compound, is accompanied by a gain or loss of combining power. In other words we do not know whether $(n\Theta H_2)''$, for example, has more or less potential chemical energy than $(\Theta H_2)''$. But we have, as I think, a right to infer that the number of atoms of water of crystallization in a salt is determined by the residual unsaturated units of affinity in the determinants of the salt itself, and will always be, for given circumstances, such as will saturate those determinants most

nearly. Thus it is conceivable that at one temperature a salt may crystallize with two, and at another with four atoms of water, the whole quantity of water being in each case diatomic, but exerting different intensities of affinity. The same principle will apply to ammonia and other compounds.

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## SCIENTIFIC INTELLIGENCE.

### I. CHEMISTRY AND PHYSICS.

1. *On a new class of homologues of cyanhydric acid.*—Prof. A. W. HOFMANN has communicated to the Academy of Sciences a very interesting and important memoir on a class of cyanids isomeric with the so-called nitriles but possessing very different properties. Cyanhydric acid, as is well known, under the influence of water takes up the elements of that body and forms ammonia and formic acid, the reaction being represented by the equation

$$\text{C}\text{NH}+2\text{H}_2\text{O}=\text{C}\text{H}_2\text{O}_2+\text{NH}_3.$$

Under the same circumstances the cyanids of the alcohol-radicals may yield one or the other of two different reactions. Thus in the case of cyanid of methyl we might have

1. $$\underset{\text{Cyanid of methyl.}}{\text{C}\text{N}\text{C}\text{H}_3}+\underset{\text{Water.}}{2\text{H}_2\text{O}}=\underset{\text{Acetic acid.}}{\text{C}_2\text{H}_4\text{O}_2}+\underset{\text{Ammonia.}}{\text{NH}_3}$$

or

2. $$\underset{\text{Cyanid of methyl.}}{\text{C}\text{N}\text{C}\text{H}_3}+\underset{\text{Water.}}{2\text{H}_2\text{O}}=\underset{\text{Formic acid.}}{\text{C}\text{H}_2\text{O}_2}+\underset{\text{Methylamine.}}{\text{NH}_2\text{C}\text{H}_3}$$

Examples of the first mode of reaction have long been known, but bodies exhibiting the second mode of reaction have not hitherto been observed. When chloroform and ammonia are heated together under pressure chlorhydric and cyanhydric acids are formed the reaction being expressed by the equation

$$\text{C}\text{HCl}_3+\text{NH}_3=3\text{HCl}+\text{C}\text{NH}.$$

Dr. Hofmann showed that this reaction takes place easily at a boiling heat when caustic potash is added to the alcoholic solution of ammonia and chloroform. On repeating this experiment with aniline instead of ammonia, Dr. Hofmann found that an oily liquid is found which passes over, on distilling the mixture, mixed with aniline. The aniline is removed by oxalic acid and the oil dried by caustic potash and distilled. It is a liquid which is green by transmitted and blue by reflected light. Its formula is $\text{C}_7\text{H}_5\text{N}$, and it is therefore isomeric with benzonitrile. The formation of this body is represented by the equation

$$\text{C}_6\text{H}_7\text{N}+\text{C}\text{HCl}_3=\text{C}_7\text{H}_5\text{N}+3\text{HCl}.$$

Dr. Hofmann calls this substance cyanid of phenyl; its physical properties are entirely different from those of benzonitrile; it unites directly with metallic cyanids, even with cyanid of silver, and by taking up water forms aniline and formic acid—

$$\text{C}_7\text{H}_5\,.\,\text{N}+2\text{H}_2\text{O}=\text{C}_6\text{H}_5\text{H}_2\text{N}+\text{C}\text{H}_2\text{O}_2.$$

It is remarkable that while the nitrids are easily decomposed by boiling alkaline solutions cyanid of phenyl is scarcely altered by these but is hydrated by the action of dilute acids.

When benzonitrile is converted into benzoic acid benzamid is formed as an intermediate product

$$\underset{\text{Benzamid.}}{\text{C}_7\text{H}_5\text{N}+\text{H}_2\text{O}=\text{C}_7\text{H}_7\text{NO}}.$$

When cyanid of phenyl forms aniline and formic acid phenyl-formamid is formed as an intermediate product

$$\underset{\text{Phenyl-formamid.}}{\text{C}_7\text{H}_5\text{N}+\text{H}_2\text{O}=\text{C}_7\text{H}_7\text{NO}}$$

But in this case another intermediate product is formed which is methenyl-diphenyl-diamine, formerly discovered by Hofmann. Ethylamine, amylamine and toluidine yield new cyanids by a similar reaction. The difference between the nitriles and the new cyanids may be explained by referring them to different types. Thus in the case of the two cyanids of methyl we have

$$\underset{\text{Hofmann's isocyanid.}}{\text{N}\left\{\begin{matrix}\text{C}^{\text{II}}\\ \text{CH}_3\end{matrix}\right.} \qquad \underset{\text{Acetonitrile.}}{\text{C}^{\text{IV}}\left\{\begin{matrix}\text{N}^{\text{III}}\\ \text{CH}_3\end{matrix}\right.}$$

To explain the relations of these substances to water we have the equations

$$\underset{\text{Isocyanid.}}{\text{N}\left\{\begin{matrix}\text{C}^{\text{II}}\\ \text{CH}_3\end{matrix}\right.}+2\text{H}_2\text{O}=\underset{\text{Methylamine.}}{\text{N}\left\{\begin{matrix}\text{H}_2\\ \text{CH}_3\end{matrix}\right.}+\underset{\text{Formic acid.}}{\text{CH}_2\text{O}_2}$$

$$\underset{\text{Acetonitrile.}}{\text{C}^{\text{IV}}\left\{\begin{matrix}\text{N}^{\text{III}}\\ \text{CH}_3\end{matrix}\right.}+2\text{H}_2\text{O}=\underset{\text{Acetic acid.}}{\text{C}^{\text{IV}}\left\{\begin{matrix}\text{CH}_3\\ \text{O}^{\text{II}}\\ \text{OH}\end{matrix}\right.}+\text{NH}_3.$$

In the same manner we easily explain the difference between the cyanetholine of Cloez and ordinary cyanic ether, and recognize in general the existence of two parallel series of cyanogen compounds. In two later communications, Dr. Hofmann has given further details of his very interesting investigation. When an alcoholic solution of ethylamine and chloroform is gradually poured into a retort containing caustic potash a violent reaction ensues, and among the products of the distillation cyanid of ethyl is formed as a liquid possessing an intolerably penetrating odor. The author has not yet carefully studied this body but gives a more detailed account of the cyanid of amyl. This last as obtained by a similar reaction is a colorless liquid smelling of amyl and of cyanhydric acid. Its vapor impresses the tongue with an insupportable bitterness and causes, like cyanhydric acid, a sense of suffocation in the throat. It boils at 137° C., which is 8° lower than its isomer capronitrile. The cyanid of amyl is but slightly attacked by alkalies but acids transform it into formic acid and amylamine. Transient intermediate products are formed in this reaction.

Anhydrous phosphoric acid, as is well known, readily converts the salts of ammonium with the fatty acids into the corresponding

nitriles. It was therefore natural to suppose that the cyanids might be formed by a similar reaction, so that, for example, formate of amylamine would yield cyanid of amyl. Dr. Hofmann found however that the action of phosphoric acid was in these cases more profound and did not yield the results expected. On the other hand the author calls attention to the fact that in the preparation of the nitriles by the action of sulphomethylate, &c., of potassium upon cyanid of potassium, the raw nitrile obtained possesses a most offensive odor, while the nitriles obtained by the action of phosphoric acid upon salts of ammonia have a very agreeable aromatic smell. On repeating the older experiments of E. Meyer upon the action of organic iodids upon cyanid of silver, Dr. Hofmann found that in this also the cyanids are formed in considerable quantities. The reaction succeeds best with the iodid of amyl, but much amylene and cyanhydric acid are formed at the same time. The author hopes to obtain the dicyanid of ethylene, $C_4H_4N_2$, isomeric with Simpson's cyanid, by the action of chloroform upon ethylene-diamin, or by treating cyanid of silver with iodid of ethylene. He considers it as probable that there exists a corresponding isomeric series of sulpho-cyanids.—*Comptes Rendus*, I, lxv, 335, 389, 448. W. G.

2. *On the same subject.*—Dr. Hofmann's communications on subject of the isomeric cyanids have called out a reclamation of priority on the part of M. Gautier, whose results agree with those of Dr. Hofmann as regards the action of the organic iodids upon cyanid of silver.—*Comptes Rendus*, lxv, 468. W. G.

3. *On certain hydrocarbons contained in coal-tar.*—Berthelot has discovered in coal-tar various hydrocarbons which had not hitherto been observed in that liquid as well as several wholly new substances of great interest. Of the former class the author mentions styrolene, $C_{16}H_8$, first in order, as one of the bodies obtained by the transformation of acetylene. The existence of cymene, $C_{20}H_{14}$, in coal-tar has been observed by several chemists, the liquid boiling at 166° C., proving to be cumolene, $C_{18}H_{12}$. Cymene boils at about 180° C., and exhibits the ordinary reactions of the benzol series. When heated to 280° C., with 80 parts of a saturated solution of iodhydric acid, cymene yields hydruret of decylene, $C_{20}H_{22}$, which boils between 155° and 160° C. The author has also found in coal-tar two hydrurets of naphtaline, $C_{20}H_{10}$, and $C_{20}H_{12}$; a hydruret of acenaphtene, $C_{24}H_{12}$, which is a liquid boiling at 260°, and a hydruret of anthracene which is also liquid and boils at 285° C. Fluorene is the name given by the author to a new hydro-carbon which separates in the distillation of the heavy oils. It is a white crystalline substance which exhibits a magnificent violet fluorescence and possesses a sweetish and irritating odor. It fuses at 113° and melts at 305°, and is very soluble in boiling alcohol. The solution of this body in sulphuric acid is colorless, but the least trace of nitrous acid colors it green, and more nitrous acid gives a violet color. Fluorene gives a red crystalline compound with picric acid.—*Comptes Rendus*, lxv, 465. W. G.

## II. MINERALOGY AND GEOLOGY.

1. *Note on the genus Palæacis* Haime, 1860 = (*Sphenopoterium* M. & W., 1866); by F. B. MEEK.—At the time the name *Sphenopoterium* was proposed for this genus by Meek and Worthen, the volume of the *Histoire Naturelle des Coralliaires*, in which the lamented Haime had a short time previously described it under the name, *Palæacis*, had not reached this country; nor was it until very recently received at any of the libraries at Washington, where we were then investigating the Illinois fossils. Owing to the fact that for a long time previous to the publication of the Illinois Report, our investigations were pursued in the west, where we were to a great extent cut off from foreign periodical scientific publications, we were also not aware of the fact, until after the printing of the Illinois Report, that von Seebach had called attention in *Zeitschr. der Deutsch. geol. Gessellsch.*, xviii, to the identity of *Palæacis* and *Sphenopoterium*:—otherwise we would have cheerfully adopted the name *Palæacis*, which has priority of date, and must take precedence.*

In first publishing a notice of this genus in 1860, we regarded it as a Coral, as Haime had also done. Milne Edwards, however, in publishing Haime's name and description, expressed some doubts, it appears, whether it is a coral, but left it provisionally where Haime had placed it, in the "*Zoantharia perforata*," or perforated section of Corals.

Being in considerable doubt in relation to the affinities of this genus at the time we were preparing the descriptions for the Illinois Report, and not being where we could have access to all the works on analogous fossils, we sent specimens of our species, *P. obtusa*, to Prof. Verrill, who has made an especial study of the corals, with the request that he should give us some suggestions in regard to the relations of the genus. After as careful an examination as could be made without preparing sections for the microscope, Prof. Verrill informed us that he was inclined to regard it as a Sponge, and not a Coral, which view was adopted by us, on his authority, in the Illinois Report.

Feeling a desire to settle more definitely, if possible, the question in relation to the affinities of this group, I recently prepared a section, as thin as the condition of the fossil would permit, of *P. obtusa*, and sent it to Prof. Verrill, who writes as follows:—

"The section of *Palæacis obtusa* sent to me is not sufficiently thin and transparent to be used with the higher powers, but I have made a somewhat careful examination of its structure as shown under powers below a quarter inch. The internal structure, like the external character, is entirely unlike any known coral, living or fossil, but agrees very well with several forms of fossil sponges. The section has been made vertically across the shorter diameter, through two of the cups. There is a central, imperfectly bounded

* Von Seebach is in error, however, in saying our description was published in 1861, as it was issued in 1860, but after Haime's, if I am not mistaken.

area beneath the cups, which is traversed by numerous irregular, crooked, sometimes branching canals, which also pass in all directions through the surrounding tissue, but in less numbers; outside of the central area there are seen radiating darker and lighter lines, which appear like minute canals. They are often branched and quite irregular. When highly magnified the whole mass seems composed of a fine spongy tissue, which varies in density between the minute canals, thus giving rise to the darker and lighter lines. There is no appearance of vesicles, or anything like septa or plates, either vertical or horizontal, or walls of any kind around the cells. The only resemblance to corals seems to be in the external form, and radiating striæ of the cells, which, however, are not true septa, and are quite irregular like the striæ in the cups of many fossil and living sponges."

It may not be out of place in this connection, to state that I have scarcely any doubts, after examining a good series of specimens, that the two species, *Palæacis umbonata* and *P. cymbia*, proposed by von Seebach, are mere varieties of *P. obtusa* M. & W., which varies greatly in the characters upon which he has proposed to separate these two forms.

### III. BOTANY AND ZOOLOGY.

1. *Monographia Salicum, auctore* N. J. Andersson.—Part I. of this Monograph of Willows, which was communicated to the Royal Swedish Academy of Sciences at Stockholm, in October, 1863, is now published, in vol. 6, of its Transactions, and separately issued, in 4to, pp. 180, with 9 plates, crowded with figures of the details of about one hundred species. We have here about three-fourths of the systematic part, in advance of the elaboration in DeCandolle's Prodromus, which is, by this time, also printed off. The second part will contain the rest of the species, the *generalia*, &c.

The system of arrangement is simple; the primary groups, or tribes, are only three, and founded on the stamens. They are: the *Pleiandræ*, with 3 to many stamens, divided into the *Tropicæ* and the *Temperatæ*, and these, each into three or four ultimate sections; *Diandræ*, with two distinct stamens, much the largest group, divided into the *Microstylæ*, of four sections, the *Podostylæ*, of ten, and the *Macrostylæ*, of four; and finally the *Synandræ*, with two sections. These names indicate clearly the characters of the groups. The present part ends with the *Podostylæ*, and with species 105. As respects the European Willows, Dr. Andersson agrees with Wimmer, (whose elegant treatise was recently noticed in this Journal,) and accordingly regards many admitted species as of hybrid origin; but he unfortunately permits several, recognized as hybrids, to retain the rank of species. Under the principal types, a series of what may be termed sub-species, are coördinated. When the concluding part of this most important and faithful monograph comes to hand, we may hope to prepare a full abstract of the work, as far as relates to North American species, east of the Rocky Mountains. Perhaps it is not too late to suggest to the author a

revocation of the name of the 92d species, *S. Novæ-anglicæ*, under which the author has combined two sub-species and several varieties, no one of which is recorded as inhabiting our New England States, or any district nearer than Saskatchawan and the Rocky Mountains. A. G.

2. *Flora Brasiliensis of* MARTIUS.—The 42d and 43d fascicles of this great work, were issued in April last. One includes the *Rosaceæ*, by Dr. J. D. Hooker, with 22 plates, done in Germany. Of the *Rosaceæ*, truly indigenous to Brazil, a little over 100 in number, 95 (under 7 genera) are of the suborder *Chrysobalanæ*. The other fasciculus is devoted to the *Combretaceæ*, by Dr. Eichler, about 65 species, under 9 genera, two of them established by Dr. Eichler, in his revision of the order, and illustrated by 15 plates. A. G.

3. *Lois de la Nomenclature, redigées et commentées* par M. ALPH. DECANDOLLE. Paris: Masson, 1867, pp. 60, 8vo.—This important pamphlet was printed, in August last, upon the request of a Committee of the Botanical Society of France, raised for organizing an International Botanical Congress, which, accordingly, was held in Paris at the close of the summer. The propositions, systematically drawn up and ably expounded by M. DeCandolle, have since been approved by this Congress, with some slight modifications, and recommended by it for general adoption. They seem to us to be, in almost all respects, judicious and timely. Upon receiving the report of the proceedings of this Congress, we may call attention to this revised code, or present to our readers a full abstract of it.

A. G.

4. Those features of the botany of Japan and adjacent regions, which are of the highest interest to us, have recently been considered by Miquel in a pamphlet, entitled—

*Sur les Affinités de la Flora du Japan avec celles de l'Asie et de l'Amerique du Nord*, (extr. des Archives Néerlandaises, ii, 1867.)—The first special notice of the now familiarly known relationship of Japan with Eastern United States botany, was probably given in this Journal, many years ago, in a review of the earlier parts of Siebold and Zuccarini's Flora Japonica. Of the article in the Memoirs of the American Academy, vol. 6, in which the subject is treated in detail, Prof. Miquel is hardly correct in stating, that it was written under the influence of the Darwinian hypothesis. Mr. Darwin's famous volume, if published, had not reached this country when this paper was read, although its leading idea was known here. All that is allowed in the memoir is, the probability "that what are termed closely related species may, in many cases, be lineal descendants from a pristine stock, just as domesticated races are;"—a proposition which, perhaps, very few naturalists would now contest.

It is by some oversight that Prof. Miquel credits only a single *Hydrangea* to North America, restricts *Malvastrum* to Eastern North America, while it is wanting east of the Mississippi, and abounds west of the Rocky Mountains, and deprives the eastern side of *Prosartes*. So far as we know, it is a mistake to credit *Symplo-*

*carpus* (*Lysichiton* being separated) to the western, as well as the eastern side; and *Cymopterus*, in the same table (p. 16), must be replaced by *Phellopterus* or *Glehnia*, whichever may secure the right of priority. It is very interesting to note that there is, in Japan, a true *Symplocarpus*, if not *S. fœtidus* itself; and even more so, that *Croomia pauciflora*, sole representative of the group in our Southern Atlantic States, has been identified in Japan. The general theoretical views in explanation of these facts of distribution, as given in the matter referred to, are repeated, and more or less reinforced, at the close of Prof. Miquel's interesting *brochure*.

A. G.

5. *Tall Trees in Australia.*—It would appear that the famous "mammoth trees" of California are not only rivalled, but surpassed in height, in Victoria Colony, Australia. The principal facts which warrant this conclusion, are collected by Dr. Ferdinand Müller, Director of the State Garden at Melbourne, in his interesting pamphlet, recently issued, upon "Australian Vegetation, considered especially in its bearings upon the occupation of the Territory, and with a view of unfolding its resources,"—from which the subjoined extracts are derived:—

"The marvellous height of some of the Australian, and especialiy Victorian trees, has become the subject of closer investigation, since of late, particularly through the miners' tracks, easier access has been afforded to the back-gullies of our mountain-system. Some astounding *data*, supported by *actual* measurements, are now on record. The highest tree previously known was a *Karri-Eucalyptus* (*Eucalyptus colossea*), measured by Mr. Pemberton Walcott, in one of the delightful glens of the Warren river of Western Australia, where it rises to approximately 400 feet high. Into the hollow trunk of this Karri, three riders, with additional packhorse, could enter and turn in it without dismounting. On the desire of the writer of these pages, Mr. D. Boyle measured a fallen tree of *Eucalyptus amygdalina*, in the deep recesses of Dandenong, and obtained for it the length of 420 feet, with proportions of width, indicated in a design of a monumental structure placed in the exhibition; while Mr. G. Klein took the measurement of a eucalyptus on the Black Spur, ten miles distant from Healsville, 480 feet high! Mr. E. B. Hayne obtained, at Dandenong, as measurements of height of a tree of *Eucalyptus amygdalina:* Length of stem from the base to the first branch, 295 feet; diameter of the stem at the first branch, 4 feet; length of stem from first branch to where its top portion was broken off, 90 feet; diameter of the stem where broken off, 3 feet; total length of stem up to place of fracture, 365 feet; girth of stem three feet from the surface, 41 feet. A still thicker tree measured, three feet from the base, 53 feet in circumference. Mr. George W. Robinson ascertained, in the back-ranges of Berwick, the circumference of a tree of *Eucalyptus amygdalina* to be 81 feet at a distance of four feet from the ground, and supposes this eucalypt, towards the sources of the Yarra and Latrobe rivers, to attain a height of half a thou-

sand feet. The same gentleman found *Fagus Cunninghami* to gain a height of 200 feet, and a circumference of 23 feet.

"It is not at all likely that, in these isolated inquiries, chance has led to the really highest trees, which the most secluded and the least accessible spots may still conceal. It seems, however, almost beyond dispute, that the trees of Australia rival in length, though evidently not in thickness, even the renowned forest-giants of California, *Sequoia Wellingtonia*, the highest of which, as far as the writer is aware, rise, in their favorite haunts at the Sierra Nevada, to about 450 feet. Still, one of the mammoth-trees measured, it is said, at an estimated height of 300 feet, 18 feet in diameter! Thus to Victorian trees, for elevation, the palm must, apparently, be conceded. A standard of comparison we possess in the spire of the Münster of Strasburg, the highest of any cathedral of the globe, which sends its lofty pinnacle to the height of 466 feet, or in the great pyramid of Cheops, 480 feet high, which, if raised in our ranges, would be overshadowed, probably, by Eucalyptus trees.

The enormous height attained by not isolated, but vast masses of our timber-trees, in the rich diluvial deposits of sheltered depressions within Victorian ranges, finds its principal explanation, perhaps, in the circumstance, that the richness of the soil is combined with a humid geniality of the climate, never sinking to the colder temperature of Tasmania, nor rising to a warmth less favorable to the strong development of these trees in New South Wales, nor ever reduced to that comparative dryness of air which, even to some entent in the mountain-ravines of South Australia, is experienced. The absence of living gigantic forms of animal life amidst these, the hugest forms of the vegetable world, is all the more striking.

Statistics of actual measurement of trees, compiled in various parts of the globe, would be replete with deep interest, not merely to science, but disclose, also, in copious instances, magnitudes of resources but little understood up to the present day. Not merely, however, in their stupendous altitude, but also in their celerity of growth, we have, in all probability, to accede to Australian trees the prize. Extensive comparisons, instituted in the Botanic Gardens of this metropolis, prove several species of Eucalyptus, more particularly *Eucalyptus globulus*, and *Eucalyptus obliqua*, as well as certain Acacias—for instance, *Acacia decurrens*, or *Acacia mollissima*—far excelling, in their ratio of development, any extra-Australian trees, even on dry and exposed spots, such into which spontaneously our blue gum-trees would not penetrate. This marvelous quickness of growth, combined with a perfect fitness to resist drought, has rendered many of our trees famed abroad, especially so in countries where the supply of fuel or of hardwoods is not readily attainable, or where for raising shelter, like around the cinchona-plantations of India, the early and copious command of tall vegetation is of imperative importance. To us here this ought to be a subject of manifold significance. I scarcely need refer to the fact, that for numerous unemployed persons, the gathering of Eucalyp-

tus seeds, of which a pound weight suffices to raise many thousand trees, might be a source of lucrative and extensive employment; but on this I wish to dwell, that in Australian vegetation we probably possess the means of obliterating the rainless zones of the globe, to spread at last woods over our deserts, and thereby to mitigate the distressing drought, and to annihilate, perhaps, even that occasionally excessive dry heat evolved by the sun's rays from the naked ground throughout extensive regions of the interior, and wafted with the current of air to the east and south, miseries from which the prevalence of sea-breezes renders the more littoral tracts of West and North Australia, almost free. But in the economy of nature the trees, beyond affording shade and shelter, and retaining humidity to the soil, serve other great purposes. Trees, ever active in sending their roots to the depth, draw unceasingly from below the surface-strata, those mineral elements of vegetable nutrition on which the life of plants absolutely depends, and which, with every dropping leaf, is left as a storage of aliment for the subsequent vegetation. How much lasting good could not be effected, then, by mere scattering of seeds of our drought-resisting acacias and eucalypts and casuarinas, at the termination of the hot season, along any watercourse, or even along the crevices of rocks, or over bare sands or hard clays, after refreshing showers? Even the rugged escarpments of the desolate ranges of Tunis, Algiers, and Morocco, might become wooded: even the Sahara itself, if it could not be conquered and rendered habitable, might have the extent of its oases vastly augmented; fertility might be secured again to the Holy Land, and rain to the Asiatic plateau, or the desert of Atacama, or timber and fuel be furnished to Natal and La Plata. An experiment, instituted on a bare ridge near our metropolis, demonstrates what may be done."

A systematic catalogue of the known trees of Australia, with indications of their territorial distribution, occupies 18 pages of this essay; from which it appears, that in Australia, no less than 950 woody plants attain a height of at least 30 feet, or thereabouts.

A. G.

6. *Report on the disastrous effects of the destruction of Forest Trees now going on so rapidly in Wisconsin;* by I. A. Lapham, J. G. Knapp, and H. Crocker, Commissioners [appointed by the Legislature of the State]. Madison, Wisconsin, 1867, pp. 104, 8vo. —The topic so properly discussed by Dr. Mühler for Australia (in the above extract), is brought home to our attention in this essay, which we trust will be widely read and seriously considered. The essay has reached our hands too late for the preparation of an abstract, and for specially noting many interesting points in matters of climatology or vegetable physiology, some few of which might be more or less criticised. But the Report as a whole strikes us as sound and able, as well as timely. A.G.

7. *Annales Musei Botanici Lugduni Batavi* edidit F. A. G. Miquel. Tom. I–III, fasc. 4. 1863–1867, fol.—Since our announcement of this work, and analysis of the contents of the earliest fas-

ciculi, in 1864, it has been so indefatigably prosecuted by Prof. Miquel, that two large volumes have been completed, and the third is well under way. A large portion is naturally devoted to Japanese botany, in the 2d and 3d volumes, under the separate heading of *Prolusio Floræ Japonicæ;* and these prolusions are also separately published. When finished, as they are likely soon to be, they will form a nearly complete exposition of Japan botany, as far as is exemplified in the rich and long-accumulated stores of the Leyden herbarium. The various and interesting contents of these volumes invite attention and remark on every side, but are already much too extensive to be compassed here. They comprise considerable monographs, or detailed articles, by collaborators, such as Mettenius, Schott, Hasskarl, DeVriese, &c., who have already passed off the stage, as well as by Sande Lacoste, Oudemans, and others, who are still active; but the greater part of the Japanese botany is Prof. Miquel's own work. In the second volume is an interesting article on *Nymphæaceæ*, by Caspary, with new sections of *Nymphæa*, and an exhaustive analysis of oriental species, a new discrimination of *N. alba* from *N. odorata*, and considerable details upon the variations of the latter, commending them, moreover, to the scrutiny of North American botanists upon the live plants. Of *Nuphar*, he admits three 5-sepalled species; *N. Japonicum* (which he fully describes and figures, both yellow and reddish forms), *luteum*, and *pumilum* (*Kalmianum*).

In characterizing his two primary sections of *Nymphæa*, Dr. Caspary proposes to restrict the botanical term "*connata*," to the case of the junction of organs which were at first separate, and to use the term "*conjunctim enata*," for the ordinary case of primordial union. It were certainly desirable, for clearness, to express the two things by different, rather than identical language; but Caspary's appropriation of the term *connate*, is open to the three objections,—1st, that it is thus divorced from the sense which it generally bears in descriptive botany, and also, 2d, which befits its literal meaning (*born with* the union), while, 3d, it does not etymologically answer well to the use he puts it to. If really needful to restrict any word to designate the comparatively rare case of post-genital union, *coalita* would be the fitter one, and would involve less change of recognized botanical language.

The depressed umbelliferous plant, published by the present writer in Cooper and Suckley's botanical report of Stevens' Pacific Railroad Exploration as *Cymopterus? littoralis*, and referred to in the account of C. Wright's Japan collection (since then collected in Japan by Maximowicz, &c.) has now two genuine names, of which the relative priority is yet uncertain. In Bentham and Hooker's Genera Plantarum, p. 905, which is by this time published in England, it is described as the genus *Phellopterus;* in Maximowicz's admirable collections it is distributed, and in Miquel's Annales, 3, p. 61 (1867), it is enumerated, but not characterized, as *Glehnia littoralis*, F. Schmidt, Fl. Sanchal, ined."

7. *Synopsis of the species of Starfishes, in the British Museum, with figures of some of the new species;* by JOHN EDWARD GRAY, Ph.D., 67 pages, quarto, with 16 plates, London, John Van Voorst. This work includes descriptions of the numerous new genera and species described by Dr. Gray in the Annals and magazine of Natural History, 1840, and the Proceedings of the Zoölogical Society of London, 1847, the plates, which were prepared for a more extended work at the time of the original publication of the species and have since been laid aside, are very accurate and beautifully executed, representing, in most cases, species not before figured. The descriptions are reproduced from the original papers with the addition of some synonyms, and lists of addittional species. It is greatly to be regretted that the loss of the types of many of the new species, especially those from the west coast of America, collected by H. Cuming, Esq., prevents their being figured or more fully described. This work, however, will be extremely valuable to all investigators of this interesting group of animals on account of the many excellent figures of rare and remarkable species. v.

## IV. ASTRONOMY.

1. *Discovery of new planet* (93).—Prof. WATSON discovered a new planet on the night of the 24th of August. It resembles a star of the 11th magnitude. The following are some of the earlier and later observations, provisionally reduced.

| Ann Arbor M. T. | | (93) $\alpha$ | (93) $\delta$ |
|---|---|---|---|
| 1867, Aug. 24, | $15^h\ 13^m\ 22^s{\cdot}1$ | $0^h\ 6^m\ 48^s{\cdot}40$ | |
| 24, | 16 5 52·0 | 0 6 46·86 | $-3°\ 11'\ 48''{\cdot}3$ |
| 25, | 10 2 42·9 | 0 6 17·04 | 3 13 7·7 |
| 25, | 10 17 51·1 | 0 6 16·80 | 3 13 7·3 |
| 26, | 10 47 51·4 | 0 5 36·35 | 4 42 55·3 |
| Oct. 15, | 9 48 5 | 23 24 30·35 | 4 42 25·3 |
| 16, | 9 48 32 | 23 23 58·00 | −4 42 20·5 |

2. *Discovery of new planet* (94).—Prof. WATSON discovered another new planet, also resembling a star of the 11th magnitude, on the night of the 6th of September. The following are the earlier and later observations.

| Ann Arbor M. T. | | (94) $\alpha$ | (94) $\delta$ |
|---|---|---|---|
| 1867, Sept. 6, | $14^h\ 48^m\ 10^s{\cdot}1$ | $0^h\ 56^m\ 33^s{\cdot}46$ | |
| 6, | 16 15 37·4 | 0 56 31·34 | $+6°\ 11'\ 14''{\cdot}5$ |
| 7, | 10 12 21·4 | 0 56 6·99 | 6 10 42·2 |
| 8, | 9 59 29·2 | 0 55 33·40 | 6 0 54·7 |
| Oct. 15, | 11 35 6 | 0 27 23·20 | 4 55 28·9 |
| 16, | 10 30 4 | 0 26 40·34 | +4 53 19·6 |

3. *Shooting Stars in August*, 1867.—At New Haven it was cloudy on the nights of 9–10th and 10–11th of August.

(1.) *At Philadelphia.*—The following is the result of the watch on the morning of the 10th, by Mr. B. V. Marsh, and Mr. C. H. Darlington, each watching independently of the other, and directing their attention mainly toward Perseus.

| *Time.* | *B. V. Marsh.* conf. | non-conf. | *C. H. Darlington.* conf. | non-conf. |
|---|---|---|---|---|
| $1^h\ 3^m$ to $1^h\ 45^m$ | 10 | 7 | 10 | 4 |
| 1 45 " 2 0 | 6 | 4 | 6 | 1 |
| 2 0 " 2 15 | 3 | 0 | 3 | 1 |
| 2 15 " 2 30 | 3 | 2 | 1 | 1 |
| In $1^h\ 27^m$ | 22 | 13 | 20 | 7 |

Seven of those seen by Mr. Marsh, and six seen by Mr. Darlington were estimated to have been bright enough to be visible in moonlight. The meteors originating near the radiant indicated the usual position, while some of the more distant seemed to proceed from Cassiopeia. Several had trains but they were not persistent nor were they very bright. The next night the sky was overcast.

(2.) *At Marathon, N. Y.*—Mr. Lewis Swift saw none during an hour's watching between $9^h$ and $10^h$ P. M., Aug. 9th. Resuming observation in the morning he saw (watching alone) in $1^h\ 10^m$, beginning at a quarter past two o'clock, 39 meteors. Thirty-four were conformable to a radiant in Perseus. Three larger than any of the 34 had a radiant in R. A. $3^h\ 30^m$, Dec. $+27°$. The paths were generally short. One not more than $\frac{1}{3}$ of the moon's diameter in length was 1° from $\gamma$ Persei. Fog prevented further observations.

The evening of the 10th was cloudy. At 3 o'clock on the morning of the 11th, 17 were counted in 30 minutes, when the fog again interfered. The radiant point for 15 of them was thought to be slightly removed from its place on the previous morning.

Aug. 12th, in $15^m$ from $2^h$ A. M., 7 were seen, all conf.
" " $60^m$ " $9\frac{1}{2}^h$ P. M., 3 " " 2 conf.
" 13th, $30^m$ " $1^h$ A. M., 2 " " both "

Mr. Swift paid special attention to the number of meteors visible, and to the location of the radiant. The latter he places on the

| | | | |
|---|---|---|---|
| 10th (A. M.), | in R. A. | $2^h\ 50^m$, | N. P. D. 37°. |
| 11th " | " | $2^h\ 55^m$, | " 38°. |
| 12th and 13th " | " | | doubtful. |

The diameter of the circle of radiation was estimated at from 6° to 8°.

(3.) *At Winchendon, Mass.*—Mr. F. W. Russell reports in the early part of August, 6 or 7 meteors per hour, all radiating from near Aquila. The first specific August meteor was seen about the 5th, and the radiant during the next few days was in Cassiopeia. It gradually passed down into Perseus.

Aug. 7th. From $9^h\ 45^m$ to $10^h\ 45^m$ P. M., 8 meteors, all from radiant near $\varepsilon$ and $\delta$ Cassiopeia.

Aug. 9th. From $12^h\ 15^m$ to $12^h\ 55^m$ A. M., 7 conf., 10 non-conf.
Aug. 9th. Evening. A few large meteors from $\eta$ Persei.
Aug. 11th. From $2^h$ to $3^h$ A. M., 28 conf., 0 non-conf.
" " " $3^h$ to $3^h\ 40^m$ " 15 " 1 "

Those marked conformable all diverged from an area 25° in diameter whose center was R. A. 44°, N. P. D. 31°. Thirty-three were from an area 5° in diameter, whose center was R. A. 47° 45′, N. P. D. 31°.

Aug. 12th. From $2^h$ to $3^h$ (hazy) 18 conf. 2 non-conf.
" " " $3^h$ to $3^h$ $30^m$ (clear) 23 " 2 "

About $\frac{3}{4}$ths of the paths produced backward, crossed a circle 16° in diameter, whose center was in R. A. 50°, N. P. D. 33°. This was considered to be as nearly as could be determined the center of the area of emanation. Mr. Russell adds: "It was emphatically evident that the position of the radiant on the 11th, was not that of the 12th. The area had moved toward $\mu$ Persei, and a little toward $\alpha$ also. Moreover the area seemed elliptical, the major axis being in declination and with a ratio to the minor axis of 5 : 2."

Mr. Russell watched alone and was interrupted frequently by the clouds and fogs.

(4.) *At Florence.*—Prof. Donati reports (Bulletitno Meteor., Sept. 1867) the following results of observations made at Florence this year.

| 1867. Aug. | No. of observers. | Number of shooting stars seen. $9^h$–$10^h$ | $10^h$–$11^h$ | $11^h$–$12^h$ | $12^h$–$1^h$ | $1^h$–$2^h$ | $2^h$–$3^h$ | $3^h$–$4^h$ | Total. |
|---|---|---|---|---|---|---|---|---|---|
| 9–10 | 3 | 6 | 35 | 25 | 29 | 51 | 61 | 30 | 237 |
| 10–11 | 4 | 32 | 48 | 39 | 50 | 122 | 160 | 106 | 557 |
| 11–12 | 3 | 27 | 27 | 30 | 34 | 53 | 94 | 86 | 351 |
| 12–13 | 2 | 6 | 24 | 12 | 14 | 18 | 28 | 28 | 130 |
| 13–14 | 1 | 3 | 6 | 6 | 6 | 9 | 7 | 10 | 47 |

Of these 1322 meteors, 972 were recorded as conformable and 350 unconformable. The maximum deduced from this table was from two to three o'clock on the morning of the 11th of August.

H. A. N.

4. *Meteoric Astronomy.* A treatise on Shooting Stars, Fireballs and Aerolites; by Prof. Daniel Kirkwood. 12mo, pp. 130, Philadelphia, J. B. Lippincott & Co. 1867.—This little treatise gives in a popular form a summary of the more important astronomical relations of the igneous meteors. In addition the author discusses the relations to the nebular hypothesis of the knowledge recently acquired respecting them. The work constitutes a valuable and interesting contribution to our literature upon this subject.

Some inadvertencies ought, however, to be corrected in any future edition. For example, he ascribes (p. 27) the change of the epoch of the August meteors from the 25–28th of July in the 9th century to the 9–11th of August in the 19th, to a motion of the nodes of their orbits along the ecliptic. The amount of motion is, however, hardly perceivable, when allowance is made for the precession of the equinoxes, and for the change of the calendar. In his list of April showers some dates are improperly included and others improperly omitted. Again, in the accounts of the April, August and December meteors, more credit, we think, should have been given to Mr. Herrick's investigations. This oversight is prob-

ably due to the fact that the author did not attempt to write the history of the subject. But the frequent references to other laborers in this field of science make the omission noticeable. H. A. N.

5. *On Meteors in the Southern hemisphere;* by Dr. E. Heis and Dr. George Neumayer. Mannheim, 1867, 24 pp. 4to, (reprinted from Dr. Neumayer's "Discussion of Met. and Magn. Obs. made at the Flagstaff Observatory.")—This memoir is very important as giving almost the only observations we have of meteors observed in the southern hemisphere. The paths of 2088 meteors seen between March, 1858, and October, 1863, at the Flagstaff Observatory, at Melbourne, are discussed by Dr. Heis. One of the most noticeable results is the lack of unusual numbers of meteors on the 10–12th of August. This was to have been expected as the radiant in Perseus is below the horizon at Melborne.

6. *Sternschnuppen und Kometen*, (Extr. from "Kalender für alle Stände") by Carl von Littrow. Vienna, 1867, pp. 42, 8vo.—This is a history and summary of the recent investigations which have led to the important discovery of the intimate relation between shooting stars and comets.

## V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Ascent of Mt. Hood, in Oregon, and determination of its height.*—Lieut. Col. Williamson, U. S. Engineers, has just communicated to the California Academy of Natural Sciences an account of his successful attempt to fix the height of this famous and much controverted mountain. We extract the essential part of it, as follows:

"The stations used were Astoria, Fort Vancouver, Fort Dalles, camp on slope of Mount Hood, and summit of Mount Hood. Observations had been taken for several years at Astoria for me by Louis Wilson, United States Tidal Observer, at 7 A. M., 2 P. M., and 9 P. M., of every day, besides hourly observations for ten days or more of each month. The cistern of this barometer is 53 feet above mean low tide.

"At Fort Vancouver, observations of the same character were commenced July 1st of this year, and are still going on. At Fort Dalles similar observations have been made since July 10th. The observations at the camp on the mountain slope were commenced at 7 P. M., on August 22d, and continued hourly (with few omissions) until 8 A. M., on the 24th. The barometer at the summit was hung up at 1.30 P. M., August 23d, and allowed to stand a half hour in free air, but protected from the direct rays of the sun. It was there adjusted and observed at 2 P. M., 2:15 P. M., and 2:30 P. M., by Mr. Heuer and Mr. Best independently, and the two records as shown to me were essentially the same. The mean reading of the barometer reduced to 32° Fah. was 19·941 inches, with an observed air temperature of 41·7 and wet bulb of 31·3.

"The height of Fort Vancouver above Astoria was computed from the mean of the simultaneous observations taken during the

months of July and August. The height of the Dalles above Fort Vancouver was deduced from the corresponding observations during twenty-one days in July, together with those for the month of August. The height of the camp on the mountain slope above Fort Vancouver, and also the height of that camp above Fort Dalles, were then separately computed from the daily means of the observations taken at the three stations during August 23d. The difference between the two should give the same result as by the direct calculations between Fort Vancouver and Fort Dalles, but, on account of the short period observed on the mountain camp, a plus correction of a little over eight feet was found necessary to the estimated height of that camp to make the three results agree.

"It then remained only to calculate the height of the summit of Mount Hood above the mountain camp. The mean of the three observations of the barometer was assumed as the nearest approximation we can have to the mean pressure for that day, as the horary oscillation at the summit is unknown.

"With regard to the mean temperature for that day, we have no positive data to determine it. We cannot take the observed temperature, as the observations were taken during the hottest part of the day.

"By consulting the hourly observations of the thermometer at the camp, I find the range there is between 63° and 43·7°, or nearly 20°, and supposing nearly as great a range of temperature on the summit, I have assumed the mean temperature there, for that day, to be 34°.

"The following are the final results of the computations:

| Stations. | Inter. alt. | Alt. above sea line. |
|---|---|---|
| Sea level at mean low tide | | 0 |
| Astoria | 53 | 53 |
| Fort Vancouver | 79 | 132 |
| Camp on mountain slope | 5,820 | 5,952 |
| Summit of Mt. Hood | 5,273 | 11,225 |

"The computations are made with new tables, which will shortly be published, and which give results similar to those by Plantamour's formula, based on Regnault's constants. They give the results somewhat higher than if Guyot's tables had been used, the latter giving the height of the summit at 11,185 feet."

The ascent was made on the twenty-third of last August, under very favorable circumstances of weather, and the instruments used (new ones, by James Green, of New York) were brought down in perfect order, and compared with the standard at Fort Vancouver.

With regard to the discordance between his result and that of a party which ascended the mountain a year earlier, and from the temperature, 180° F., at which they observed water to boil, deduced a height of 17,600 feet, Col. Williamson remarks:

"The reason is that the instruments used were unreliable, and this method of computing the altitude defective. With a boiling-point apparatus (or thermo-barometer, as it is called), even of the most approved kind, the results by boiling water are far inferior to those by the cistern-barometer; but if the observations are

made by a common thermometer, with small places for degrees, as was the case in this instance, and the instrument not protected from drafts of air, the results are utterly unreliable, and, therefore, worse than worthless."

Prof. J. D. Whitney, State Geologist of California, who visited Oregon this summer, writes (in a private letter) concerning the same ascent: "The measurement of Mt. Hood published abroad by Prof. Alphonso Wood was in reality made by Rev. Mr. Atkinson, of Portland, who carried up his own thermometer (one of Kendall's, with a heavy metallic scale), made the observations, and calculated them by a rule which he found in Porter's Chemistry."

In our May number (vol. xliii, p. 416–9), we quoted from the Proceedings of the Royal Geographical Society a story told by a Rev. H. K. Hines of his own ascent of Mt. Hood, in July of last year, wherein that gentleman distinctly conveys the impression that he, too, had boiled water at 180° upon the summit, and calculated from it a height for the mountain of 17,640 feet, thus confirming Mr. Atkinson's result with a signal, not to say singular, closeness. Prof. Whitney says farther, with reference to this: "Mr. Hines never carried up any instruments at all, as I ascertained on the spot from those who went up with him. I had felt certain of this before, for the simple reason that he had given figures identical with those of Atkinson and Wood, which were evidently erroneous; as also because, in the account which he published in the newspapers on his return, he said never a word about having made any measurements, or having any instruments with him. It is, then, a clear case of piracy."*

Prof. Whitney himself made, during his brief visit, the best trigonometrical observations that circumstances permitted upon the heights of Hood, St. Helens, and Adams, and his results, as yet only rudely worked out, gave him over 12,000 feet for Hood, and about 1,000 feet less for the other two, which appear to be nearly of the same height. Mt. Rainier he was unable to observe, but thinks, judging by the eye alone, that it is the highest of all the mountains of Oregon and Washington Territory. Col. Williamson refers to these measurements as tending to confirm the accuracy of his own; and, while hoping that other parties, with good instruments, will repeat his observations, he yet expresses his confidence that the result he has reached will not be varied a hundred feet.

2. *American Association for the Advancement of Science.*— The sixteenth meeting of the American Association for the Advancement of Science was held at Burlington, Vt., in August last, commencing on Wednesday the 21st and closing on the Monday evening following. The officers of the meeting were Prof. J. S. Newberry, President, Prof. J. Lovering, Permanent Secretary, Prof. C. S. Lyman, General Secretary. The Vice President, Prof.

* Mr. Hines's claim is not put forward *quite* so categorically as it was represented in our reprint of this article. By an error of the press, his statement, "This was found to be 17,460 feet high, the thermometer standing at 180°," is printed "This *we* found," etc. On the difference between *was* and *we* he would possibly found a claim to save his character for veracity.

W. Gibbs, and the Treasurer, Dr. A. L. Elwyn, were not present. Dr. B. A. Gould was elected chairman of Section A, Mathematics and Physics, and Prof. J. W. Dawson, of Section B, Natural History and Geology.

The whole number of papers read was 63—30 in Section A, and 33 in Section B. The papers, generally, would compare favorably in interest and importance with those of previous meetings.

The attendance of members was about the same as at Buffalo—some seventy-five or eighty. Though not as great, for various reasons, as before the war, it was yet larger than was generally anticipated, and abundantly indicative of the abiding interest felt in the Association by the scientific men of the country. The spirit of the meeting was excellent throughout, and the discussions often of the highest interest. A noticeable feature was the number of the younger men of science who took part, some of them for the first time, and the impression of high promise made by many of them in their several fields of effort. At the same time, the absence of many of the older men, so active in former meetings, could not but be generally remarked. Some had died—among them Prof. Bache; others, like Prof. Henry, were kept away by illness, or other causes.

The meeting was in all respects a successful one, and the Association may now be regarded as permanently re-established, with every prospect of as full an attendance of members, and as happy an influence on the science and the scientific men of the country in the future as at any former period. The success of the meeting was promoted in no small degree by the active coöperation of many of the citizens of Burlington, and the hospitalities and courtesies extended to the Association, both by individuals and corporations, contributed largely to the comfort and enjoyment of the members. The excursion on the Lake and to the Gorge of the Ausable, by invitation of the Champlain Transportation Company, and that to Mount Mansfield by invitation of W. H. H. Bingham, Esq., deserve to be particularly mentioned.

In default of the customary address by the retiring president, (Dr. Barnard being in Europe) the address this year was given by the president, Prof. Newberry, on "Modern Scientific investigation—its Methods and Tendencies."

Among the general business transacted was the appointment of a commission, "To examine the Linnean rules of Zoological Nomenclature by the light of the suggestions and examples of recent writers, and to prepare a code of laws and recommendations in conformity with just modern usage, to be submitted to the Association at the next meeting." The commission, as appointed, consists of Profs. J. D. Dana, J. Wyman, S. F. Baird, J. Leidy, J. S. Newberry, J. W. Dawson, Wm. Stimpson, S. H. Scudder and F. W. Putnam.

Prof. John Torrey was appointed on the committee of Weights and Measures in place of the late Prof. Bache.

Dr. B. A. Gould was appointed to prepare an address on the Life and Services of Prof. Bache, to be delivered at the next meeting.

The next meeting was appointed to be held in Chicago, commencing on Wednesday, the 5th of August, 1868.

The officers elected for that meeting, are Dr. B. A. Gould, President, Col. Charles Whittlesey, Vice President, Prof. J. Lovering, Permanent Secretary, Prof. A. P. Rockwell, General Secretary, Dr. A. L. Elwyn, Treasurer.

The following is a list of the papers read.

IN SECTION A.—MATHEMATICS AND PHYSICS.

1. On the optical method of studying Sound; Prof. J. Lovering.
2. New determination of the distance of the Sun; Prof. Simon Newcomb.
3. Apparatus for illustrating Wave Motion; Prof. C. S. Lyman.
4. On the Theories of Boussingault and Thenard of the difference between Stale and Freshened Bread; Prof. E. N. Horsford.
5. On the relative values of Gold and Silver for a series of years; E. B. Elliott.
6. Remarks on Meteorological results deduced from the new method of registration; Prof. G. W. Hough.
7. Remarks on the laws of winds, with some account of progress in the investigation of the same; Prof. J. H. Coffin.
8. On the Periodicity of the Aurora; Prof. J. Lovering.
9. Occupations of the population classified; E. B. Elliott.
10. On the determination of latitude from observations in the prime vertical; Prof. W. A. Rogers.
11. On new diagrams and derivative symbols, illustrating the prominent characteristics of the chemical elements; Prof. S. D. Tillman.
12. On the Velocity of transmission of signals by the Electromagnetic Telegraph; Dr. B. A. Gould.
13. On the Structure of Ice in its relations to the sudden disappearance of Ice on Lake Champlain; Prof. E. N. Horsford.
14. The Geodetic Triangulation of the Coast of New England, Prof. Bache, late Superintendent of the U. S. Coast Survey; Prof. J. E. Hilgard.
15. Preliminary notice of Experiments on Snow at temperatures below 32° Farenheit; Prof. E. Hungerford.
16. Remarks on Personal Equation in Transit Observations; Prof. G. W. Hough.
17. Tellurium a Metal; Dr. L. Bradley.
18. On a new method of Measuring Musical intervals upon a spiral projection; S. D. Tillman.
19. Suggestions on the Scientific and Practical Relations of Wood Spirit; Prof. J. Hyatt.
20. On certain Laws of Production and Trade; E. B. Elliott.
21. On the Conversion of Iron into Steel by means of carburetted Hydrogen Gas; Prof. Jas. Hyatt.
22. On the Knowledge of the Satellites of Jupiter before the time of Galileo; Prof. Jas. Hyatt.
23. On the Effects of Sunshine on Fires; Prof. E. N. Horsford.
24. On the Communications of Vibrations; Prof. B. Peirce, read by Prof. Lovering.

25. Indian Architecture; L. H. Morgan.
26. Notes on the Duke of Argyle's theory of the flight of Birds, with illustrations derived from the Trochilidae; L. E. Chittenden.
27. On the use of Months for Dates; J. F. Holton.
28. On Elliptic Integrals by Series; David Trowbridge, presented by Dr. B. A. Gould.
29. On Euler's Universal Formulæ for the Summation of Series; David Trowbridge, presented by Dr. B. A. Gould.
30. On Observations of Venus near inferior conjunction; Prof. C. S. Lyman.

IN SECTION B.—NATURAL HISTORY, AND GEOLOGY.

1. The Distribution of Precious Metals in the United States; Col. Charles Whittlesey.
2. The Geological Relations of the Mastodon and Fossil Elephant of North America; Prof. James Hall.
3. Considerations drawn from the Study of the Orthoptera of North America; Samuel H. Scudder.
4. Traces of Ancient Glaciers in the White Mts.; G. L. Vose.
5. The Origin of the so-called Lignilites or Epsomites; Prof. O. C. Marsh.
6. The Geographical Distribution of the Sediments and the Fossils of the Hamilton, Portage, and Chemung groups of New York; Prof. James Hall.
7. The distribution of Limnæa megasoma and cognate genera; L. E. Chittenden.
8. Upon some remarkable Fossil Fishes obtained by Rev. H. Herzer, from the Devonian Rocks at Delaware, Ohio; Prof. J. S. Newberry.
9. The Fossil Insects of North America; S. H. Scudder.
10. The Winooski Marbles of Colchester, Vt.; Prof. C. H. Hitchcock.
11. The Zoological affinities of the Tabulate Corals; Prof. A. E. Verrill.
12. The Coal Measures of Illinois; Prof. A. H. Worthen.
13. New Points in the Geology of Nova Scotia and New Brunswick; Prof. J. W. Dawson.
14. On some New Fossil Sponges from the Lower Silurian: Prof. O. C. Marsh.
15. On the occurrance of Fossil Sponges in the successive groups of the Paleozoic Series; Prof. James Hall.
16. The American Beaver; Lewis H. Morgan.
17. The Distortion and Metamorphosis of Pebbles in Conglomerates; C. H. Hitchcock.
18. On some Fossil Reptiles and Fishes from the Carboniferous Strata of Ohio, Kentucky, and Illinois; Prof. J. S. Newberry.
19. Cotta's Law of the Earth's Development; R. W. Raymond.
20. On Mountain Masses of Iron Ore in the United States; Col. Charles Whittlesey.
21. On the Lower Silurian Brown Hematite Beds of America; B. S. Lyman.

22. Explanations of the Geological Map of Maine; Prof. C. H. Hitchcock.
23. On the Geographical Distribution of Radiates on the West Coast of America; Prof. A. E. Verrill.
24. Considerations relating to the Climate of the Glacial Epoch in North America; Prof. Edward Hungerford.
25. Depression of the Sea during the Glacial Period; Col. Chas. Whittlesey.
26. Ripton Sea Beaches; Prof. Edward Hungerford.
27. On the Cretaceous and Tertiary Flora of North America; Prof. J. S. Newberry.
28. On certain Effects produced upon Fossils by Weathering; Prof. O. C. Marsh.
29. Geology of Vermont; Prof. C. H. Hitchcock.
30. The Insect Fauna of the summit of Mt. Washington as compared with that of Labrador; Dr. A. S. Packard, jr.
31. Remarks on the Ichthyological Fauna of Lake Champlain; F. W. Putnam.
32. The Embryology of Libellula (Diplax), with notes on the Morphology of Insects, and the classification of the Neuroptera; Dr. A. S. Packard, Jr.
33. On the Flowering of Plants; James Hyatt.

3. *National Academy of Sciences.*—At the recent August meeting of the National Academy of Sciences, held at Hartford, the following papers were presented.

1. The structural character of the Selachians; L. Agassiz.
2. Protest against modern nomenclature in Zoology; L. Agassiz.
3. On homocercy and heterocercy; L. Agassiz.
4. On the significance of classes in the Animal kingdom; L. Agassiz.
5. On sterility among Skates; L. Agassiz.
6. The fifth pair of nerves and the organ of hearing in Skates; L. Agassiz.
7. On periodical orvulation in Sharks and Skates; L. Agassiz.
8. The circulation of blood in Selachians; L. Agassiz.
9. Parasitic Crustacea in the gills of Sharks; L. Agassiz.
10. On the duration of the electric discharge; O. N. Rood.
11. On new processes in analytical chemistry; W. Gibbs.
12. On certain points in the theory of atomicities; W. Gibbs.
13. Spectroscopic notices; W. Gibbs.
14. On determination of wave lengths by the method of comparison; W. Gibbs.
15. Embryology and affinities of Cyclopterus; L. Agassiz.
16. Algebras; Benjamin Peirce.
17. The limitations and conditions of associated linear algebra; Benjamin Peirce.
18. Single, double and triple linear associative algebras; Benjamin Peirce.
19. Quadruple linear associative algebra; Benjamin Peirce.
20. The precision of the equinoxes and rotation as resulting from

the theory of the gyroscope, with remarks explanatory of the deviation of rifled projectiles; G. Barnard.

21. Notes on a problem in curvature; T. Hill.

22. Observations in 1866 and 1867 of right ascensions of stars observed by d'Agelet in 1783–5; B. A. Gould.

23. Determinations of the proper motions of stars first observed by d'Agelet; B. A. Gould.

24. Remarks on the geological relations of the Mastodon and Fossil Elephant, suggested by the discovery of the Cohoes Mastodon; Jas. Hall.

25. On the value of certain groups in the geological series when studied in their geographical extension; Jas. Hall.

26. On a process of integration used in the case of a planet's orbit disturbed by small forces; Theodore Strong.

4. *Mineralogical Nomenclature.*—In my article on Mineralogical Nomenclature, page 146 of this volume, I observe that names after persons were not used by the ancients. I failed to allude to a case cited from Pliny (xxxvi, 67) by von Kobell, in his excellent *Geschichte der Mineralogie* (Munich, 1864)—that of *Obsidian*, or more correctly *Obsian*, named after Obsius, who Pliny says discovered the substance in Ethiopia,—an example referred to in 1790 by Werner in a defense of his own use of such names (Bergm. J., i, 103, 1790). But this is not strictly an example of a personal name of the kind intended. For Pliny uses *Obsian* not as a substantive but as an adjective; the mineral was not *Obsian* but *Obsian glass* or *Obsian stone; vitrum obsianum*, *lapis obsianus*, and *obsiana* [vitra], occurring in the course of the paragraph. The addition of the termination *ite* to Obsian would, according to mineralogical method, make a name equivalent to Pliny's *lapis obsianus*. Names of persons ending in *an* (as Octavian, Tertullian) were common among the Romans; and this is so far reason for avoiding the termination in names of stones.

Some critics question the existence of the reputed Obsius, and reject Pliny's explanation. J. D. DANA.

5. *British Association.*—The British Association was in session at Dundee in September last, commencing its session on Wednesday the 4th. The names of over 2000 attendants on the meeting were enrolled, of whom more than 700 were ladies. The President of the year, the Duke of Buccleuch, opened the meeting with a brief and popular address, much less labored and scientific than the Association has been accustomed to hear from its President. The receipts for the year past amounted to £787, and the expenditures to £777. We have not space at this time for a notice of the various papers presented.

6. *Walker Prizes of the Boston Socicty of Natural History.*—The subjects for the annual prizes of 1868 and 1869, are as follows: For 1868, Adduce and discuss the evidences of the coëxistence of man and extinct animals with the view of determining the limits of his antiquity. For 1869, On the range of Arctic and Alpine plants in North America, with an enumeration of the species. On the nature of the prizes, see vol. xl, p. 137, of this Journal.

## V. MISCELLANEOUS BIBLIOGRAPHY.

1. *The Mechanical Theory of Heat with its application to the Steam Engine, and to the physical properties of bodies;* by R. CLAUSIUS, Prof. of Physics in the University of Zurich, edited by Prof. T. Archer Hirst, F.R.S., with an introduction by Professor Tyndall. London, John Van Voorst, 1867. 8vo, pp. 376.—This volume consists of nine memoirs by Prof. Clausius which were originally published in Poggendorff's Annalen and elsewhere. In 1864 the author prepared for the press a collected edition of them, adding notes and appendices. The present volume is an English edition containing, however, an additional memoir (the 9th) which has appeared since 1864. The 5th memoir was reprinted in this Journal, (II, xxii and xxiii) from the Philosophical Magazine.

The following are the titles to the memoirs. Introduction; On the treatment of differential equations which are not directly integrable. 1st memoir, On the moving force of heat, and the laws of heat which may be deduced therefrom. 2d, On the deportment of vapor during its expansion under different circumstances. 3d, On the theoretic connexion of two empirical laws relating to the tension and the latent heat of different vapors. 4th, On a modified form of the second fundamental theorem in the mechanical theory of heat. 5th, On the application of the mechanical theory of heat to the steam engine. 6th. On the application of the theorem of the equivalence of transformations to interior work. 7th, On an axiom in the mechanical theory of heat. 8th, On the concentration of rays of heat and light, and on the limits of its action. 9th, On several convenient forms of the fundamental equations of the mechanical theory of heat.

2. *Condition and doings of the Boston Society of Natural History.* Boston, 1867.—In this report are included the reports of the Custodian, the Librarian, the curators of the various special departments, and the Treasurer, together with obituary notices of two prominent and active members of the society, Dr. A. A. Gould and Dr. Henry Bryant. The reports show continued enterprise and activity in all departments of the society, and a highly encouraging financial condition. During the year two important bequests have been received, one of $20,090 from P. P. Pope, Esq., and $10,000, with a valuable collection of shells from Miss S. P. Pratt. Important improvements have been made in the building, for the better accommodation of the rapidly increasing library and collections. The publication of both the Memoirs and Proceedings have gone forward with unusual rapidity, and a volume of the Correspondence and Entomological notes of Dr. T. W. Harris is announced as authorized to be published. During the year forty-four papers have been presented to the Society from thirty-one individuals.

3. *The Culture demanded by Modern Life.*—Under this title Messrs. Appleton & Co. have published a collection of addresses and arguments in favor of scientific training by Faraday, Tyndall, and a number of the most eminent English and American scientists

of the present day. This excellent and useful compilation is due to Prof. E. L. Youmans whose labors in the cause of science are familiar to all and to whom we owe a collection of papers on the correlation of forces as well as original scientific works of great merit. Prof. Youmans has done good service to the cause of scientific education in our country by the preparation of this work. He has brought together a mass of argument from scattered and, to most readers, inaccessible sources. These papers treat the subject from about every point of view. They vary, as might be expected, in ability, but they are without exception readable and interesting. Mr. Youmans's own lecture on the scientific study of human nature is very valuable and suggestive and his introduction to the reader is well written and appropriate. The gem of the work is, in our opinion the noble and characteristic discourse of Faraday on the education of the judgment, and we are glad to see his words put into a permanent form. In conclusion we heartily thank Prof. Youmans for his work and commend it to the earnest attention of teachers. G.

4. *On the distribution of temperature in the lower region of the earth's atmosphere;* by Professor HENRY HENNESSY, F.R.S. (Ext. Roy. Irish Acad.) 4to, 58 pp.—Professor Hennessy discusses in this memoir the daily change of temperature with reference to the geographical position of the stations. By drawing a line through the places that enjoy the same temperature at the same instant of absolute time, he constructs what he denominates a *synthermal* line. A map containing such lines for $4^h$ A. M. and $2^h$ P. M. Greenwich mean time accompanies the memoir.

5. *Die Chemie der austrocknenden Oele, ihre Bereitung und ihre technische Anwendung in Künsten und Gewerben;* von G. J. MULDER. Nach der holländischen Original-Ausgabe bearbeitet von J. Müller, Berlin, 1867.—Mulder being asked what paint would best serve to protect iron from rusting, was unable to give an answer satisfactory to himself without first experimentally investigating the nature of paint and finding out wherein the drying of oils consists. He has brought to bear on this practical subject, his well known accuracy, tact, and thoroughness, and has obtained commensurate results. He has resolutely and perseveringly grappled the previously evasive Proteus of the drying oils, through its several shapes, and has at last elicited facts and principles which are all the more important for their bearing on matters of everyday life, —for their relation to the arts and to art. Most of his experiments were made on linseed oil, but he also devoted some attention to poppyseed oil and nut oil. The chief and distinctive constituent of all is "linolein" which consists of glycerin and "linoleic acid." The author tried in vain to obtain pure linoleic acid, for the more he worked with it the more it became contaminated with products of oxydation; and, as it is one of the very weak acids, he found it exceedingly difficult to produce salts which he could be sure were quite pure and normal. But there can be little doubt that its composition is $HO,C_{32}H_{27}O_3$. Linoleic acid being exposed in thin layers to the air, in a few days becomes oxydized

to "linoxic acid,"—a sticky substance, like turpentine. By several months farther exposure, the linoxic acid dries and becomes "linoxyn," $C_{32}H_{27}O_{11}$,—an amorphous, tough, leathery matter insoluble in water, alcohol, ether, or dilute acids, but dissolving in alkalis to reproduce linoxates. Its best proper solvent is a mixture of alcohol and chloroform. Linoleate of lead readily oxydizes in the air to a white linoxate, which is not glutinous, but dry, hard, and brittle. And linseed oil boiled with a very little oxyd of lead so as to contain a small quantity of linoleate of lead, dries as well in a few days as isolated linoleic acid does in so many months. There are two linoxyns, the white and the red, and there are corresponding white and red linoxic acids. The white modifications become red by being heated to 80° C., and the red turn white again by continued exposure to sunlight. The browning of white paint in dark places, is owing to the gradual change of white linoxyn into red. Four linoxic acids are mentioned, having the same properties, but differing in respect to color and to the amount of HO in combination. White linoxic acid formed by the oxydation of linoleate of lead, is $HO,C_{32}H_{25}O_9$; that produced by the oxydation of free linoleic acid in the air, is $HO,C_{32}H_{25}O_9+2HO$. Red linoxic acid when separated from red linoxate of lead by chlorhydric acid and dried at 100° C., is $C_{32}H_{25}O_9$. The second of the above white linoxic acids on being heated for some time in a water bath, loses 6·7 per cent and leaves a blood red linoxic acid of the composition $HO,C_{32}H_{25}O_9$. It will be noticed that linoxyn, which is an indifferent substance, has a composition intermediate between this latter red linoxic acid and the white from which it is formed; but of course in linoxyn the molecular arrangement is different. Linoleic anhydrid,—$C_{32}H_{27}O_3$,—completes the list of peculiar substances which exist or may be formed in drying oils. More or less of it is always formed during the boiling of such oils, and it adds much to the goodness of boiled oil. It is an unalterable, elastic matter, like caoutchouc that has been melted.

Poppy seed oil and nut oil differ from linseed oil in containing laurin instead of palmitin, and their linolein gives only the white variety linoxyn. Hence not being liable to turn brown in the dark, they are better for artists' use. Linseed oil consists of about 80 p. c. of linolein, 10 p. c. of elaïn, and 10 p. c. of myristin and palmitin.

Mulder calls attention to what may be called the respiration of drying oils, for when they are spread out over a great surface they absorb oxygen and give out carbonic acid, like the blood of living animals. In drying, linseed oil increases in weight to the amount of from seven to twelve per cent over and above what it loses in the form of water and carbonic acid, together with small portions of acetic, formic, and acrylic acids. In the first place the glycerin of the linolein is all decomposed and carried off. Then the glycerin of the other constituents is gradually destroyed, so that at the end of three months not a trace of it is to be found. When this stage of the drying is completed, there remain linoxyn and palmitic, myristic, and elaic acids, and the paint is dry and flexible

and elastic. But oxydation still goes on, though very slowly, and the fatty acids disappear. Finally the linoxyn itself undergoes decay and becomes unserviceable in binding colors or in protecting the painted surface.

The albuminous or mucilaginous matter which has so long figured in the books to account for slowness in the drying of unboiled oil, Mulder has searched for carefully but in vain; and he finds that fresh oil treated by any method which should simply remove albumen or mucilage, still dries no better than before. And, after all, this inappreciable substance, if it were present, would fail to explain what it was invented to account for: since there is no known reason why a matter that helps some oils oxydize to become rancid, should hinder others from oxydizing to become dry. It is therefore high time for science to consign this nonentity to the limbo of obsolete follies.

The oxyds and acetates of lead act as driers, not by precipitating albuminous matters, but by forming a little lineolate of lead, which oxydizes readily and communicates its activity to the oil itself. The addition of some manganese salts, such as the borate, accelerates the drying, because the loosely held oxyd of manganese oxydizes in the air and awakens the activity of the surrounding oil. No metallic oxyds or salts can act as driers unless they are brought into a state to combine chemically with the oil. Thus red oxyd of iron and zinc white and oxyd of tin are entirely inert. Sulphate of zinc or sulphate of manganese may act when oxyd of lead is added to combine with the sulphuric acid and set the other oxyd free; but without such addition, they are useless; and the oxyd of lead required for the decomposition would do more good if used alone. But oil treated with any driers by mere digestion, though it may dry quickly, can never be so good as oil boiled with suitable additions; because in boiling some linoleic anhydrid is formed, which being more adhesive and elastic than linoxyn, adds much to the value of oil for paint. The author, discarding numerous nonsensical receipts which are extant, recommends for preparing a colorless drying oil, which leaves nothing to be desired, to boil common linseed oil two hours with three per cent of red lead, filter it, and expose it to sunlight in large shallow vessels, the air over it being frequently renewed.

Mulder returning at length to the problem which gave rise to the investigation, rejects oil paints as unsuitable to prevent the rusting of iron, and concludes that coal tar contains the best materials for a protecting coat.

The book contains a great deal that is new, and the author has been, to use his own expression, "Getren dem Grundsatze, welcher uns Niederländean von Jugend auf beigebracht wird, nicht so ohne Weiteres dahin zu schreiben und sicher bei Behandlung von Gegenständen die Geschichte nicht zu vergessen." Of course he does not entirely exhaust his subject, but science is greatly enriched by this work, and it constitutes a masterly contribution to the chemistry of the arts. J. M. O.

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